Review of Literature
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Despite prevention and control efforts, infectious diseases remain an important global problem, causing over 13 million deaths every year. One of the most challenging aspects of infectious disease is the emergence of several bacteria that are resistant to conventional antibiotic therapy. These resistant bacteria are increasingly responsible for human diseases of the intestinal tract, lungs, skin and urinary tract.

Human behavior has provided more opportunities for exposure to and transmission of new and re-emerging infection and has increased selective pressure for antimicrobial resistance. Antibiotic resistance may be developed in clinical pathogens due to frequent misuse or overuse of antibiotics. Acute infection may lead to chronic due to lack of knowledge and awareness of antibiotic sensitivity pattern.

Rosemarie et al (1994) reported an 11-year review of invasive *H. influenzae* disease in Research institute for tropical medicine. It was done to determine the disease spectrum, clinical picture, prevailing serotypes of the organism and its antimicrobial resistance pattern in Philippines. The incidence rate of invasive *H. influenzae* disease among hospitalized pediatric patients was 1.31%. A total of 84 patients had positive cultures from the blood, CSF or both for *H. influenzae*. Over half (59.5%) of the isolates were recovered from blood samples. Majority of the patients (87.1%) were less than 2 years old. Age ranged from 2 months to 9 years with a mean of 20.6 months and peak incidence was in the 6 to 12 months of age. Sixty-one (72.6%) had pulmonary findings, 35 (41.7%) had meningitis. Anemia was a prominent feature. Mortality rate was 26.2%. *H. influenzae* serotype b was the most common (68.3%). Antibiotic sensitivity tests showed that resistance to penicillin, ampicillin and chloramphenicol was 16.4%, 4.6% and 2.3% respectively.

Isolation of *Staphylococcus aureus* and coagulase negative *Staphylococci* (CONS) from blood culture of bacteraemic patients was performed for methicillin resistance in 1993 and 1996 by Jesudason et al (1997). An increase in methicillin resistance among these isolates was observed in 1996. In 1993, 32.6% isolates of *Staphylococcus aureus* were methicillin resistant; this was increased to 45.7% in 1996. Methicillin resistances in CONS were 1.6% and 14.6% respectively in 1993 and 1996.
Prats et al (2000) investigated the trends in resistance to antimicrobial agents used for therapy. They evaluated 3,797 enteropathogenic bacteria, Campylobacter, Salmonella, Shigella and Yersinia, between 1985-1987 and 1995-1998. The greater increase in the rate of resistance was observed in Campylobacter jejuni for quinolones (from 1 to 82%) and tetracycline (from 23 to 72%). In gastroenteric salmonellae for ampicillin (from 8 to 44%), chloramphenicol (from 1.7 to 26%), and trimethoprim-sulfamethoxazole and nalidixic acid (from less than 0.5 to 11%). Multidrug resistance was detected in several Salmonella serotypes. In the 1995-1998 period, 76% of Shigella strains were resistant to trimethoprim-sulfamethoxazole, 43% were resistant to ampicillin and 39% were resistant to chloramphenicol. Seventy-two percent of Yersinia enterocolitica strains were resistant to streptomycin, 45% were resistant to sulfonamides, 28% were resistant to trimethoprim-sulfamethoxazole and 20% were resistant to chloramphenicol.

Reacher et al (2000) conducted a study on determination of causes, trends and antibiotic resistance in bacteria isolated from blood in England and Wales from 1990 to 1998. There was an upward trend in total number of reports of bacteraemia. There was a substantial increase in reports of Staphylococcus aureus resistant to methicillin, Streptococcus pneumoniae to penicillin and erythromycin while Enterococcus faecalis and Enterococcus faeci to vancomycin. No increase was seen in resistance of Escherichia coli to gentamicin.

Mumtaz et al (2002) collected pus specimens from wounds and abscesses of patients and cultured it on MacConkey and blood agar plates in microbiology section, pathology laboratory of Rawalpindi Medical College during the years 1996-1998. Staphylococcus aureus was the most common pathogen (49%) followed by Escherichia coli (25.9%), Klebsiella spp. (9.5%), Pseudomonas aeruginosa (8.6%), Proteus spp. (4%) and Acinetobactor spp. (2.7%). Quinolones, aminoglycosides and cephalosporins were found to be the most effective antimicrobial agents in vitro while amoxycillin, minocycline, and trimethoprim- sulphamethaxazole were least effective against isolated pathogens.

Hryniewicz et al (2001) studied susceptibility pattern of pathogens responsible for urinary tract infections (UTIs) in Poland to currently used antimicrobial agents. A multicentre study of 141 pathogens from hospital-acquired infections and 460 pathogens from community-acquired infections were isolated between July 1998 and May 1999. The most prevalent etiological agent was Escherichia coli (73.0%), followed by Proteus spp. (8.9%) and other species of Enterobacteriaceae (9.6%). Few
community infections were caused by Gram-positive bacteria (2.2%). Gram-positive cocci were isolated more frequently from a hospital setting (14.1%) and the most common was Enterococcus spp. (8.5%). Pseudomonas aeruginosa was found only among hospital isolates and was responsible for 10.7% of infections. E. coli isolates from both community and hospital infections were highly susceptible to many antimicrobial agents with the exception of those isolates producing extended-spectrum beta-lactamases (ESBLs). Of all Enterobacteriaceae tested, 38 strains (6.9%) were capable of producing ESBLs.

A nationwide study with all of the isolates of Pseudomonas aeruginosa collected in a week from 136 hospitals in Spain was conducted by Bouza et al (1999). The data of 1,014 isolates included resistance to the following antimicrobials, piperacillin-tazobactam (7%), meropenem (8%), amikacin (9%), tobramycin (10%), piperacillin (10%), ticarcillin (13%), imipenem (14%), ceftazidime (15%), cefepime (17%), ciprofloxacin (23%), aztreonam (23%), ofloxacin (30%) and gentamicin (31%).

Ergin and Mutlu (1999) isolated Pseudomonas aeruginosa from Akdeniz University hospital. They determined the distribution rates of Pseudomonas aeruginosa in clinics and its resistance to antibiotics. The antibiotic resistance rates were detected by minimal inhibitory concentration (MIC). The clinical and specimen distribution properties of Pseudomonas were evaluated based on their resistance pattern. Pseudomonas was the fourth common bacteria in all isolates. Tracheal aspirates, sputum and wound, pus were important sources for Pseudomonas aeruginosa isolation in intensive and nonintensive care units of surgery wards (SW-ICU, SW-nonICU) (p<0.05). On the basis of MIC criteria, the resistance ratios of the isolates to ceftriaxone, cefotaxime, ceftazidime, imipenem, ofloxacin and ciprofloxacin were 8.4%, 15.0%, 13.3%, 0.0%, 11.6% and 8.3% respectively.

Henwood et al (1999) reported prevalence of antibiotic resistance amongst Gram-positive cocci in 25 UK hospitals. It was studied over an 8-month period in 1999. A total of 3770 isolates were tested by the sentinel laboratories using the E-test. These bacteria comprised 1000 Pneumococci, 1005 Staphylococcus aureus, 769 coagulase-negative Staphylococci (CONS) and 996 Enterococci. The prevalence of penicillin-resistant Streptococcus pneumoniae, vancomycin-resistant Enterococci and methicillin-resistant Staphylococcus aureus (MRSA) varied widely amongst the sentinel laboratories. The resistance rates to methicillin among Staphylococcus aureus and CONS were 19.2% and 38.9% respectively, with MRSA rates in individual sentinel sites ranging from 0 to 43%. No glycopeptide resistance was seen.
in *Staphylococcus aureus*, but 6.5% of CONS isolates were teicoplanin resistant and 0.5% were vancomycin resistant. Vancomycin resistance was much more frequent among *Enterococcus faecium* (24.1%) than *Enterococcus faecalis* (0.5%) (P<0.05), with most resistant isolates carrying vanA. The rate of penicillin resistance in *Pneumococci* was 8.9% and this resistance was predominantly intermediate (7.9%), with only six hospitals reporting isolates with high level of resistance. The prevalence of erythromycin resistance among *Pneumococci* was 12.3%, with the majority of resistant isolates having the macrolide efflux mechanism mediated by mefE. All the organisms tested were susceptible to linezolid with MICs in the range 0.12-4 mg/L. The modal MICs of linezolid were 1 mg/L for CONS and *Pneumococci* and 2 mg/L for *Staphylococcus aureus* and *Enterococci*. The study concluded that linezolid was the most potent agent tested against Gram-positive cocci, including multiresistant strains and as such may prove a valuable therapeutic option for the management of Gram-positive infections in the hospital.

Nagmoti et al (1999) conducted a bacteriological study of pyoderma in Belgaum. Commonest isolate was *Staphylococcus aureus* (45%) followed by *Streptococcus pyogenes* (35%), *Escherichia coli* (5%), *Citrobacter* (1%), while *Staphylococcus* and *Streptococcus* together (14%). *Staphylococcus* showed highest resistance to ampicillin (85%), followed by penicillin (78%), tetracycline (40%) and ciprofloxacin (15%). *Streptococci* and other Gram-negative isolates were sensitive to most of the drugs tested. Most of the strains of *Staphylococci* were nontypable (42.2%) suggesting the possible emergence of new strains.

Mathur et al (2003) evaluated spectrum of soft tissue infections caused by beta haemolytic *Streptococci* in a tertiary care hospital of North India. The laboratory records of all patients with beta haemolytic *Streptococci* isolated from soft tissues between January 1996 and December 2000 were reviewed. Detailed clinical, laboratory and demographic data was recorded for all patients. A total of 39288 samples from soft tissue infections were received in the bacteriology laboratory for bacterial culture during the study period. Beta haemolytic *Streptococci* were recovered from 205 samples. Of these, 56% isolates were obtained from patients of suspected osteomyelitis. A seasonal pattern was observed with maximum isolation occurring in the winter season. Group A was the commonest isolate (75%) followed by group B *Streptococci* (11%). Group C and G beta haemolytic *Streptococci* together accounted for about 3% of all the isolates. All the isolates were sensitive to penicillin.
McLoughlin and Joseph (2003) reported prevalence of resistance of the various urinary tract infection (UTI) pathogens obtained from patients in an urban pediatric emergency department (PED) and identified the risk factors for infection with resistant strains. The data were collected retrospectively in an urban, academic PED in North Eastern Florida. The microbiology-computerized database was used to identify all positive urine cultures from October 1999 through June 2000. Urine specimens of patients aged 17 years or less were collected in the ED. The urine specimens grew cultures with greater than 10,000 colony forming units (CFU) per milliliter on MacConkey agar or blood agar.

Ahmad et al (2000) determined sensitivity pattern of 197 bacterial isolates from Sudanese patients with diarrhea or urinary tract infections. *Shigella dysenteriae* type 1 and enteropathogenic *Escherichia coli* showed high resistance rates against the commonly used antimicrobial agents: ampicillin, amoxycillin, chloramphenicol, tetracycline, co-trimoxazole, nalidixic acid, sulfonamide and neomycin. The uropathogens were completely sensitive to ciprofloxacin. Resistance to ampicillin, amoxycillin, tetracycline, co-trimoxazole and sulfonamide was the most frequent pattern. The common urinary tract pathogens *Escherichia coli*, *Klebsiella pneumoniae* and *Proteus mirabilis* showed high rates of resistance to ampicillin, amoxycillin, co-trimoxazole, tetracycline, sulfonamide, trimethoprim, streptomycin and carbenicillin.

Kanungo et al (2000) worked on prevalence of Pneumococcal carriage in school going children of urban and rural Pondicherry. Throat swabs of school going healthy children between 5-10 years of age were examined for Pneumococcal carriage, by standard bacteriological techniques. A prevalence rate of 24.3% isolates was noted. There was no difference in the carriage rate among the rural children when compared to urban children. No age, sex or geographical variation of Pneumococcal carriage was noted. A statistically significant seasonal variation, however, was seen. Carriage rate increased during the colder months and was found to be the highest in the months of March and November.

Dimitrov et al (2004) studied the antibiotic susceptibility pattern of community acquired urinary tract infection in a Kuwait hospital during a period of 7 years (1991-2001). The 14,042 urine samples were processed from which 1,606 (11.4%) yielded significant growth of pathogens. More organisms isolated from women (74.5%) than from men (25.5%). *Escherichia coli* (48.65%), *Klebsiella* spp. (12.2%), coagulase negative *Staphylococci* (10.3%), group B *Streptococci* (8.7%) and
*Pseudomonas aeruginosa* (4.8%) were the most prevalent organisms. The isolates were susceptible to third generation cephalosporins, cefotaxime (96%), ceftriaxone (96%) and ceftazidime (97%) respectively. Multiresistance was detected in 53.8% and 41% of *E.coli* and *Klebsiella* spp. respectively. Amikacin (99.4% susceptibility) was more active than gentamicin (90% susceptibility). The study demonstrated an increasing resistance to ciprofloxacin and gentamicin among UTI pathogens in the community.

The relative frequency and drug resistance pattern of bacteria isolated from blood cultures in Razi Hospital laboratory was examined by Sobhani et al (2004). A total of 311 positive blood cultures during 1999 to 2001 were examined. Variables under study were bacterial strains, antibiotics examined in antibiogram, microbial resistance and patients' age and sex. The most common isolated bacteria was *Salmonella typhi* (22.2%) and the least common ones was *Citrobacter* (1.6%). The highest antibiotic resistance was seen against amoxycillin (88.4%). The proportion of males to females was 1:1 and the most common age group was 15-44 years old (47.3%).

Song et al (2004) reported high prevalence of antimicrobial resistance among clinical *Streptococcus pneumoniae* isolated in Asia. A total of 685 clinical *Streptococcus pneumoniae* isolates from patients with Pneumococcal diseases were collected from 14 centers in 11 Asian countries from January 2000 to June 2001. In vitro susceptibilities of the isolates to 14 antimicrobial agents were determined by the broth microdilution test. Among the isolates tested, 483 (52.4%) were not susceptible to penicillin, 23% were intermediate sensitive and 29.4% were penicillin resistant. Isolates from Vietnam showed the highest prevalence of penicillin resistance (71.4%), followed by those from Korea (54.8%), Hong Kong (43.2%) and Taiwan (38.6%). The penicillin MICs at which 90% of isolates were inhibited (MIC99s) were 4 mg/L among isolates from Vietnam, Hong Kong, Korea and Taiwan. The prevalence of erythromycin resistance was also very high in Vietnam (92.1%), Taiwan (86%), Korea (80.6%), Hong Kong (76.8%) and China (73.9%). The MIC99s of erythromycin were >32 mg/L among isolates from Korea, Vietnam, China, Taiwan, Singapore, Malaysia and Hong Kong. Isolates from Hong Kong showed the highest rate of ciprofloxacin resistance (11.8%), followed by isolates from Sri Lanka (9.5%), the Phillipines (9.1%) and Korea (6.5%).

Dutta et al (2001) performed a study on in vitro susceptibility of isolated *Salmonella typhi* strains to chloramphenicol, ciprofloxacin and ceftriaxone. A total of
140 children, aged 3-10 years, clinically diagnosed as having typhoid fever. The children without any clinical response after 12-14 days of ciprofloxacin therapy were screened for *Salmonella typhi* by blood culture. In the bacteriologically positive children, the treatment was changed to intravenous ceftriaxone for 14 days. The isolated strains of *Salmonella typhi* were tested for in vitro antimicrobial susceptibility. All isolated *Salmonella typhi* strains were uniformly (100%) susceptible to ciprofloxacin and ceftriaxone but 50% of the strains were resistant to chloramphenicol. The MIC values of chloramphenicol, ciprofloxacin and ceftriaxone ranged between 125-500μg/mL, 0.0625-0.5μg/mL and <0.0625 μg/mL respectively.

Nafeesa *et al* (2001) conducted a study on resistance of *Staphylococcus aureus* against commonly used antibiotics. A total of 60 isolates of *Staphylococcus aureus*, 30 each from upper respiratory tract as well as from post operative wound infections were subjected to antibiogram studies. *Staphylococcus aureus* isolates from upper respiratory tract were found 30%, 53.3% and 43.3% resistant to ciprofloxacin, amoxycillin and chloramphenicol respectively. A similar pattern of antibiotic resistance was observed in the bacterial isolates from postoperative sepsis. Susceptibility to ciprofloxacin, amoxycillin and chloramphenicol in such cases was found only to be 43.3%, 10% and 3.33% respectively.

Brown and Izundu (2004) assessed antibiotic resistance in clinical isolates of *Pseudomonas aeruginosa* in Jamaica. A total of 51 isolates of *Pseudomonas aeruginosa* obtained from 162 clinical specimens from major hospitals and laboratories in Jamaica were analyzed between May and August 2002. Isolates were tested against 18 different antibiotics by disk diffusion method. Organisms were cultured from wound swabs (56%), vaginal swabs (10.5%) and ear swab (42.5%). Overall, the highest percentage rates of resistance were found for cefaclor (100%), nalidixic acid (82.4%), kanamycin (76.5%) and trimethoprim/sulfamethoxazole (56.9%). Resistance rate were 25.5% or lower for tobramycin, gentamicin, polymixyn B, cefotaxime, ciprofloxacin, norfloxacin, piperacillin, carbapenems and amikacin. Forty-one isolates showed intermediate sensitivity to most of the antipseudomonal antibiotics and the remaining 70 isolates were resistant to eight or more antibiotics. In multiresistant isolates, most of which were hospital isolates and all were resistant to tetracycline, trimethoprim/sulfamethoxazole and highly (80-90%) resistant to kanamycin, ciprofloxacin and norfloxacin.

A retrospective study on soft tissue infections and their antimicrobial susceptibility pattern was performed by Mohanty *et al* (2004) in one year during
January to December 2002. A total of 5039 pus samples received in the bacteriology laboratory were analyzed. Out of a total of 2783 bacterial isolates, comprised of 1504 gram negative bacilli and 1279 gram positive cocci. *Staphylococcus aureus* was the commonest isolate followed by *Escherichia coli* and *Pseudomonas* species. Methicillin resistance in *Staphylococcus aureus* was found to be 38.56%. High level aminoglycoside resistance was observed in 53.3% *Enterococci* and 66.75% of the gram-negative bacilli. These organisms were extended spectrum beta-lactamase producers. Rifampicin and vancomycin showed best activity for *Staphylococcus aureus*, while piperacillin/tazobactam combination showed best activity for gram negative bacilli.

Oteo *et al* (2004) studied antibiotic susceptibility pattern of invasive *Staphylococcus aureus* obtained in Spain (2000-2002). Forty hospitals participated in this study, covering nearly 30% of the Spanish population. They used their usual methods to perform microbiological studies. A questionnaire with hospital patient and specimen data was completed for each isolate. Results were included in a database and analyzed with WHONET 5 software. Invasive *Staphylococcus aureus* was isolated from blood samples of 3113 patients. Its resistance was 24.5% to oxacillin, 25.4% to ciprofloxacin, 25.2% to erythromycin and 12.1% to gentamicin. Gentamicin resistance decreased from 16.6% to 9.7% from year 2000 to 2002 respectively. Multidrug resistance was observed in 68.1% of oxacillin-resistant isolates. More prevalent multidrug resistance profiles consisted of oxacillin-ciprofloxacin-erythromycin-gentamicin (7.4%) and oxacillin-ciprofloxacin-erythromycin (7.1%). Oxacillin resistance was significantly higher in nosocomial isolates than in those implicated in community-onset infections (26.7% versus 14.2%), in isolates from adults than in those from children (27.3% versus 4.7%), in hospitals with >500 beds than in those with <500 beds (31.1% versus 18.3%) and in isolates from Intensive Care Units than in those from other departments (39.3% versus 24%).

Shigemura *et al* (2005) analyzed the occurrence and antimicrobial susceptibility of uropathogens isolated at Kobe University Hospitals between 1983 and 2002. This study was performed with three patients group, they studied 15,925 urine isolates obtained from those patients who were diagnosed with urinary tract infection. Overall, *Enterococcus faecalis* was the most frequently isolated pathogen, followed by *Pseudomonas aeruginosa* and *Escherichia coli*. The frequency of *Staphylococcus aureus* increased over time, corresponding to an increase in the occurrence of methicillin resistant *Staphylococcus aureus* (MRSA). In addition the
rate of isolation of *Serratia marcescens* also increased over time, especially among patients with urinary tract catheters.

Gupta *et al* (2002) evaluated antibiotic resistance pattern in uropathogens from inpatients and out patients. The isolated pathogens were *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Acinetobacter baumanii* and *Enterococcus faecalis*. Antibiotic susceptibility pattern of these isolates revealed that for outpatients, first generation cephalosporins, nitrofurantoin, norfloxacin and ciprofloxacin were effective for treatment of urinary tract infection but for inpatients, amino glycosides and third generation cephalosporins need to be advocated because the organism for nosocomial UTI exhibit a high degree of drug resistance. Co-trimoxazole in the present study was no longer found to be effective for UTI as all the uropathogens showed high degree of resistance to it.

Mohan *et al* (2002) performed a study on 192 strains of Coagulase negative *Staphylococci* (CONS). It showed that *Staphylococcus epidermidis* 158 (82.29%) was the most common species, isolated from all clinical specimens followed by *Staphylococcus saprophyticus* 30 (15.62%) isolated mainly from urine. Slime production was exhibited by 77 (48.7%) strains of *Staphylococcus epidermidis* and 8 (26.6%) of *Staphylococcus saprophyticus*. The difference in the slime producing activity was statistically significant (*p*<0.005). Antibiotic susceptibility testing of these isolates against 15 commonly used antibiotics showed multidrug resistance with more than 90% resistance to penicillin, more than 50% resistance to cephalexin and ciprofloxacin and more than 20% resistance to methicillin.

Pais *et al* (2002) determined antibiotic sensitivity of uropathogens in St. John's medical college and Hospital, Bangalore. Their retrospective study was done to compare between prescriber's preferences for antibiotics in urinary tract infections (UTIs) and to that of antibiotic sensitivity pattern observed in the culture sensitivity report. The commonest causative organism in both inpatients and outpatients was *Escherichia coli*. The other organisms isolated included *Pseudomonas*, *Klebsiella*, *Enterobacter* spp. and *Staphylococcus aureus*. *Escherichia coli* was most commonly found in outpatients. The 5 most commonly preferred antibiotic choices of doctors for inpatients and outpatients were norfloxacin, ciprofloxacin, cephalexin, co-trimoxazole and amikacin. *Escherichia coli* showed high degree of resistance to co-trimoxazole, ampicillin and also to the fluoroquinolones. All of the isolates were resistant to ofloxacin and pefloxacin.
Samy et al (2003) reported the incidence of MRSA infection and the effect of patients colonization by MRSA on the incidence of graft infection in the Burns Unit at Mansora University Hospitals in the period from January 2001 to January 2002. Sterile swabs were taken from the nostrils, hair, hand and skin graft of the patients. The swabs were identified by morphological characteristics, Gram staining and coagulase production. The results revealed that colonization of skin with MRSA increased the risk of graft infection while nostril and hair colonization didn't significantly increase the incidence of graft infection. The production of enterotoxins A, B, C and D were evaluated in the isolated strains by reversed passive latex agglutination. Enterotoxin A was the most prevalent in the examined isolates. MRSA may have contributed to graft breakdown.

Ehinmidu (2003) evaluated the antibiotic susceptibility patterns of urine bacterial isolates in Zaria, Nigeria. A total of 206 bacteria were isolated from 150 urine samples of men, who are commonly reported in urinary tract infection. The prevalence of the *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli* isolates from the urine samples was 53.4%, 43.3% and 40.7% respectively. The bacterial isolates were most prevalent in urine samples of commercial sex workers (30.58%). The bacterial isolate were highly sensitive to ciprofloxacin and gentamicin. The multiple antibiotic resistant indices (MARI) obtained in this study indicated that a very large proportion of bacterial isolates have been exposed to several antibiotics. Multiple antibiotics resistance was highest in students of faculty of pharmaceutical science as well as in commercial sex workers due to frequent usage of antibiotics.

Mathur et al (2003) conducted a study on the antimicrobial sensitivity of *Enterococci* isolated during a one year period from clinical samples of patients admitted to a tertiary care hospital of Delhi. A total of 444 isolates of *Enterococcus faecalis* were screened for antimicrobial susceptibility by the disk diffusion technique as recommended by the National Committee for Clinical Laboratory Standards (NCCLS). Screening for vancomycin resistance was done by the vancomycin screen agar method recommended by NCCLS, which was confirmed by determination of minimum inhibitory concentration (MIC) using microbroth dilution and E-test methods. Vancomycin resistance phenotypes were determined by polymerase chain reaction. A total of 115 (26%) isolates had high-level aminoglycoside resistance, 293 (66%) were resistant to ampicillin, 391 (88%) to ciprofloxacin and 377 (85%) to erythromycin. Vancomycin resistance was found in 5 (1%) isolates, of which 4 had van A phenotype and 1 had van B phenotype.
Mohanty et al (2003) determined antimicrobial resistance profile of urinary tract pathogens in Department of Microbiology, AIIMS at New Delhi. They reported that 5.92% of isolates were sensitive to all antibiotics tested. Multiresistance was observed in 90% isolates. Isolates showed 59.5% resistance to amikacin. They also reported that Gram negative bacilli were most susceptible to nitrofurantoin (55.75%) except *Pseudomonas*. *Staphylococcus aureus* was found sensitive to vancomycin.

Prais et al (2003) reported the bacterial susceptibility to oral antibiotics in community acquired urinary tract infection. They observed that nitrofurantoin, cefuroxime and nalidixic acid were found to be sensitive to uropathogens while ampicillin and cephalaxin were found to be resistant to uropathogens.

Raksha et al (2003) worked on the occurrence of uropathogenic *Escherichia coli* (UPEC) in cases with urinary tract infection. A total of 220 cases from urinary tract infection and 50 stool samples from apparently healthy individuals were collected. The colonies identified as *Escherichia coli* were screened for virulence factors namely haemolysin, Mannose Resistant and Mannose Sensitive Haemagglutination (MRHA, MSHA), Cell surface hydrophobicity and Serum resistance by recommended methods. Among 220 cases 91 (41.36%) were haemolytic, 68 (30.9%) showed MRHA, 58 (26.35%) were cell surface hydrophobicity positive and 72 (32.72%) were serum resistant. In 50 controls, 3 (6%) were haemolytic, 6 (12%) showed MRHA, 9 (18%) showed cell surface hydrophobicity and 12 (24%) were serum resistant. The difference between cases and controls for haemolysis and MRHA were significant (p<0.001 and p<0.01 respectively). A total of 14 atypical *Escherichia coli* were isolated from urine and all showed the presence of one or the other virulence markers. Out of 18 mucoid *Escherichia coli* isolated 10 were serum resistant. Among the 15 *Escherichia coli* isolated from patients with pyelonephritis, 8 were UPEC. Out of 220 urinary isolates, 151 could be labelled as UPEC.

Astal (2004) assessed common clinically significant isolates and determined their antimicrobial susceptibility pattern. A retrospective study for bacterial isolates from clinical sources including urine, pus, blood and cerebrospinal fluid was conducted. Bacterial susceptibility testing was done by the standardized disk agar diffusion technique. The study has been conducted in microbiology laboratory in the governmental hospitals of Gaza Strip, Palestine (11 hospitals with 1376 beds) during four different months (January, April, July and October, 2003). A total of 2944 isolates (924 Gram positive and 1920 Gram negative) were scrutinized. The resistance of *Staphylococcus aureus* was 73.2% to amoxycillin and 1.8% to
vancomycin. Among *Streptococcus pneumoniae*, 40.4% isolates were resistant to penicillin and 7.4% to erythromycin.

Gazi et al (2004) determined the carriage rates and antimicrobial resistance of the bacterial pathogens in children aged 6-14 years in Manisa, Turkey. A total of 1022 children were included from nine schools selected randomly. Throat swabs were cultured for presence of bacteria and the bacteria were identified using standard microbiological methods. Out of 1022 children, 240 (23.4%) harbored *Streptococcus pneumoniae*, 162 (15.8%) *Haemophilus influenzae*, 30 (2.9%) *Streptococcus pyogenes* and 82 (8%) *Moraxella catarrhalis* in their oropharynx. For *Streptococcus pneumoniae* overall 17.6% of the isolates were intermediately resistant and 7% were resistant to penicillin. To erythromycin, trimethoprim/sulphamethoxasole (TMP/SMX) and chloramphenicol the resistance was 13.7%, 9.1% and 1.6% respectively. Ampicillin resistance observed in 20.9% of *Haemophilus influenzae* isolates and was associated with the presence of beta-lactamase, except two isolates which are interpreted as beta-lactamase-negative ampicillin resistant strains. Resistance of *Haemophilus influenzae* to TMP/SMX, chloramphenicol, azithromycin, cefaclor and amoxycillin/clavulanic acid was 14.2%, 2.4%, 1.8%, 1.2% and 1.2% respectively. *Moraxella catarrhalis* isolates produced beta-lactamase in 80.5% of the cases and all were susceptible to macrolides and clavulanic acid/amoxycillin combination. The highest rate of resistance of 17% was for TMP/SMX. One (3.3%) isolate of *S. pyogenes* was resistant to macrolides tested.

Dhanorkar and Tambekar (2004) studied multidrug resistance pattern in clinical isolates in Amravati city. More than 1000 clinical specimens such as urine, blood, pus, sputum and other body fluids were investigated for presence of bacterial pathogens. Most prominent pathogen from urine was recorded *Escherichia coli* (46%) followed by *Enterococci* (24%), *Staphylococci* (13%), *Klebsiella* (9%), from blood *Staphylococci* (31%), *Listeria* spp. (28%), *Diplococci* (10%) and *Clostridium* (10%) were isolated. In pus specimen, *Staphylococci* (79%), *Streptococci* (14%), *Pseudomonas* (6%) were detected while in sputum *Staphylococci* (46%), *Streptococci* (19%). Yeast (19%) and *Diplococci* (14%) were found to be present. In other body fluids the most prominent organism was *Staphylococcus*. The antibiotic sensitivity test of these pathogens was done by disc diffusion method. These pathogens were found to be resistant to antibiotics cefaclor, cefotaxime, ciprofloxacin, nalidixic acid, kanamycin, cefazolin, cefturoxime, norfloxacin, penicillin, ampicillin, co-trimoxazole, lincomycin, clavulanic and erythromycin and sensitive to amikacin, netilmicin, meropenem, moxalactam, levofloxacin, cefprozil, amoxyclyve, linezolid and cefdinir.
Olayinka et al (2004) monitored the 878 pathogens in the hospital in general and specialized units to determine prevalence and antibiotic resistance pattern of specific pathogens. All clinical samples from the surgical units of Ahmadu Bello University Teaching Hospital, Zaria over a 24-month period were processed and Pseudomonas aeruginosa isolates were characterized and identified using standard microbiological procedures. A total of 1,452 clinical specimens were processed and 878 pathogenic bacteria were isolated within the study period. There were 92 Pseudomonas aeruginosa isolates, giving a prevalence level of 10.5%. Most of the isolates were from urine (51.1%) and wounds (41.3%). A total of 19.6% of the isolates were resistant to three or more of the antibiotics tested, with the most prevalent resistance pattern being ceftazidime, gentamicin, pefloxacin and ofloxacin.

Saini et al (2004) investigated the surgical infections and reported that such infections were mostly polymicrobial, involving both aerobes and anaerobes. One hundred seventeen cases were included, among which 51 were closed abscesses, 25 were secondary peritonitis, 22 were necrotizing fasciitis and 19 wounds had devitalized tissue. Various isolates were Escherichia coli, Staphylococcus aureus, Klebsiella spp., Pseudomonas aeruginosa, Bacteroides fragilis and Peptostreptococcus spp. Antibiotic susceptibility pattern of these isolates revealed that the most effective antibiotics for Staphylococcus aureus were clindamycin (79.1% sensitive) and cefuroxime (70.8% sensitive). For gram negatives the most effective antibiotics were cefotaxime, ceftriaxone, amikacin and ciprofloxacin (35% resistance). The greatest degree of multidrug resistance was found in Pseudomonas aeruginosa (52.9%) followed by Klebsiella spp. (33.3%), Proteus spp. (33.3%), Escherichia coli (22.2%) and Staphylococcus aureus (12.5%). All the anaerobes that isolated were 100% sensitive to metronidazole and chloramphenicol, followed by clindamycin (95% to 100%).

Tankihwale et al (2004) studied an extended spectrum of beta lactamase (ESBL) of uropathogens, and also the susceptibility patterns of ESBL and non-ESBL producers. Out of total 217 uropathogens (49.8%) isolates of Escherichia coli were found to be the most common organism followed by Klebsiella pneumoniae (37.8%), Pseudomonas aeruginosa (6.5%), Staphylococcus saprophyticus (1.84%), Acinetobacter spp. (1.4%), Proteus mirabilis and Staphylococcus aureus (0.9% each). Each one strain of Candida albicans and Enterobacter spp. was also isolated. Antibiogram revealed that 82% and 79.6% isolates were resistant to co-trimoxazole and ampicillin respectively. Gram negative bacilli were resistant to nalidixic acid. Eighty-seven isolates were cephoxamate resistant Gram-negative bacilli. Of these 42 (48.3%) were...
found to be ESBL producer. *Escherichia coli*, *Klebsiella pneumoniae* and *Acinetobacter* were ESBL producing species. Multidrug resistance was found to be significantly more (90.5%) in ESBL producing isolates than non-ESBL producers (68.9%).

Ako-Nai et al (2005) studied the antibiotic resistant profile of *Staphylococcus aureus* and selected coagulase negative *Staphylococci*. Of the 178 *Staphylococcal* isolates evaluated, 122 were *Staphylococcus aureus* and the rest were coagulase negative *Staphylococci*. The 68% of *Staphylococcus aureus* isolates were resistant to amoxicillin, 69.8% to cloxacillin, 51% to augmentin and 71% to tetracycline. However, only 2.6% of the 116 *Staphylococcus aureus* isolates tested were resistant to gentamicin making the drug a reliable therapeutic agent in the event of failure of other antimicrobials in treating *Staphylococcal* infections. Resistance to the penicillin drugs was mediated by the elaboration of beta-lactamase by both pathogenic and non-pathogenic *Staphylococci*. The study showed a high rate of cloxacillin resistance and possibly the existence of methicillin resistance among these strains. The 80% of the *Staphylococcus aureus* strains were multidrug resistant with 25% of these resistant to three different antibiotics, 21% to 4 and 6.8% to 6 different drugs. Only 1.2% of these *Staphylococcus aureus* strains were resistant to 7 different antimicrobials underscoring the need to reduce the high incidence of multidrug resistance.

Dhanorkar and Tambekar (2005) conducted a study on the prevalence and antibiogram of potential bacterial pathogens in clinical specimens collected from different hospitals in Amravati city. A total of 2127 clinical specimens include 1471 (69.38%) urine, 351 (16.56%) pus, 48 (2.26%) sputum and 140 (6.50%) other body fluids were investigated for culture isolation and their antibiogram. Most prominent pathogens from urine were *Escherichia coli*, *Enterococci* spp. followed by *Klebsiella pneumoniae*, *Proteus mirabilis*, from blood *Staphylococcus aureus*, *Listeria* spp., and *Diplococci*. In pus *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa* while in sputum *Staphylococcus aureus*, yeast and *Diplococci pneumoniae* were detected. In other body fluids the most prominent organism detected were *Staphylococcus aureus*. The antibiogram of these pathogens showed high resistance to cephalixin, cefuroxime, ciprofloxacin, amoxicillin, ampicillin, cefotaxime, cefazolin, erythromycin, vancomycin, penicillin and lincomycin. Maximum sensitivity was found to amikacin, levofloxacin, meropenem, gatifloxacin and gentamycin.
Hussain et al (2005) reported the bacterial etiology of urinary tract infection and their antibiogram in Assam. A total of 350 urine samples from suspected cases of urinary tract infections of women aged 22-25 years were examined. *Escherichia coli* (74%), *Klebsiella* spp. (10%), *Pseudomonas aeruginosa* (6%), *Staphylococcus aureus* (5%), *Enterococci* (3%) and single isolate of *Proteus* spp. were isolated. Antibiotic sensitivity test showed that *E. coli* strain was highly sensitive to amikacin, gentamicin and sparfloxacain (100% to each) followed by ofloxacin and chloramphenicol (99% to each), ciprofloxacain (90%), cephotoxime and norfloxacain (72% to each). Antibiogram implied that new generation quinolones, amikacin, gentamicin and chloramphenicol could effectively used in UTI.

Meremikwu et al (2005) reported epidemiology and antimicrobial susceptibility pattern of common pathogens isolated from blood cultures of children with suspected septicaemia in Calabar, Nigeria. One thousand two hundred and one blood samples were analyzed from children aged 0-15 years, admitted into the children's wards of the University of Calabar Teaching Hospital, Calabar, Nigeria with features suggesting septicaemia. Samples were collected under aseptic conditions and cultured for aerobic and anaerobic organisms. Isolates were identified using bacteriologic and biochemical methods and antibiotic sensitivity was determined by agar diffusion method using standard antibiotic discs. Bacteria were isolated in 552 (48.9%) of samples with highest rates among newborns. The most frequent isolates were *Staphylococcus aureus* (48.7%) and coliforms (23.4%). Results showed high susceptibilities to the cephalosporins (ceftiraxone-100%: 83.2% respectively cefuroxime-100%: 76.5% respectively) and macrolides (azithromycin-100%: 92.9% respectively) for *Staphylococcus aureus* and coliforms respectively. This study underscored the importance of septicaemia as a common cause of febrile illness in children and provided information on common prevalent etiologic agents and drug susceptibilities of the commonest pathogens.

The antibiotic resistance pattern of the urinary pathogens isolated from hospitalised patients at a tertiary care hospital in Western Nepal studied by Das et al (2006). Three urine samples were collected by the mid-stream "clean catch" method from 1,680 clinically-suspected cases of urinary tract infections from inpatients of various clinical departments during one year. The samples were tested microbiologically by standard procedures. Antibiotic susceptibility of the isolated pathogens was tested for commonly used antibiotics by Kirby-Bauer technique according to NCCLS guidelines. Significant bacteriuria
was present in 71.7% of the samples, 17% were sterile, 4.8% showed insignificant bacteriuria and 6.5% showed non-pathogenic bacteriuria. The most common pathogens isolated were *Escherichia coli* (59.4%), *Klebsiella* spp. (15.7%) and *Enterococcus faecalis* (8.1%). The mean susceptibility was high for amikacin (87.2%), ciprofloxacin (74.8%), ceftazidime (71.5%) and gentamicin (70.4%) but low for nitrofurantoin (35%), cephalaxin (49.7%) and ampicillin (50.5%). *Escherichia coli* was found to be most susceptible to amikacin (98%) followed by gentamicin (87.9%), ceftazidime (80.8%), norfloxacin (78.4%) and co-trimoxazole (77.9%).

Elmanama *et al* (2006) reported the antibiotic resistance of *Pseudomonas aeruginosa* isolates from 4 types of clinical specimens (pus, urine and blood). Pus was the major source of *Pseudomonas aeruginosa* isolates (64%). The highest percentage rates of resistance was found against amoxycillin (99%), cephalexin (98.5%), cefaclor (97.4%), doxycycline (96.2%), trimethoprim / Sulfamethoxazole (94.7%) and Nalidixic acid (93.5%). Ciprofloxacin was the most effective of all the tested antimicrobials.

Inabo and Obanibi (2006) worked on antimicrobial susceptibility of some urinary tract clinical isolates to commonly used antibiotics. They reported that *Escherichia coli* had the highest percentage occurrence (58.8%). *Escherichia coli* was most sensitive to ciprofloxacin, pefloxacin and resistant to minocycline, nalidixic acid, cefuroxime and co-trimoxazole. They also reported that *Klebsiella* spp., *Proteus* spp. and *Staphylococcus* spp. were moderately sensitive to ciprofloxacin. The study concluded that all organisms were resistant to minocycline, cefuroxime and ciprofloxacin. These antibiotics appeared to be drug of choice for treatment of urinary tract infection.

Rahman *et al* (2006) evaluated the spectrum of organism causing neonatal sepsis in Peshawar, Pakistan and assessed their sensitivity to various groups of drugs. Blood taken from newborn babies admitted to the special care baby unit at the Khyber Teaching Hospital with a clinical diagnosis of neonatal sepsis was cultured. A total of 1598 blood cultures were analyzed, out of which 1003 (62.8%) were positive. *Escherichia coli* was the common organism found (36.6%), followed by *Staphylococcus aureus* (29.5%), *Pseudomonas* (22.4%), *Klebsiella* (7.6%) and *Proteus* (3.8%). No group B *Streptococcus* was grown. *Listeria monocytogenes* was found in one cerebrospinal fluid culture. *Escherichia coli* and *Pseudomonas* showed a high degree of resistance to cephalosporin (cefotaxime, ceftazidime and
ceftriaxone) and low resistance to drugs not used for new born babies (ofloxacin, ciprofloxacin and enoxabid). *Staphylococcus aureus* showed a low resistance to all their group of antibiotics.

**Tambekar et al** (2006a) determined antibacterial susceptibility of urinary tract pathogens to commonly used antibiotics. A total of 174 urine samples were analyzed for isolation and identification, 68 found to be the cause of significant bacteriuria with *Escherichia coli* (59%) followed by *Pseudomonas aeruginosa* (15%), *Klebsiella pneumoniae* (10%), *Proteus mirabilis* (9%), *Staphylococcus aureus* (6%) and *Citrobacter freundii* (1%). The urinary tract infections were found to most frequent in female (63%) than male (37%). The isolated uropathogens showed resistance to ampicillin (87%), co-trimoxazole (91%), nalidixic acid (68%) and sensitive to nitrofurantoin (52%), cefotaxime (54%) and norfloxacin (71%).

**Tambekar et al** (2006b; Tambekar et al (2007a) reported prevalence, profile and antibiotic susceptibility pattern of bacterial isolates from blood samples in Amravati city. A total of 448 blood samples were analyzed. Out of which 405 (92%) samples were from aerobic blood culture and 43 (8%) samples were from anaerobic blood culture. From aerobic blood culture 111 (27%) pathogens and from anaerobic blood culture 6 (13%) pathogens were identified. In aerobic culture *Staphylococcus aureus* 71 (64.54%) was the most common cause of bacteraemia followed by *Listeria monocytogenes* 17 (15.45%), *Diplococcus* spp. 7 (6.36%), *Salmonella typhi* 6 (5.45%), *Streptococcus* spp. 4 (3.63%), *Klebsiella pneumoniae* 3 (2.72%), while *Campylobacter* spp., *Escherichia coli* and *Haemophilus influenzae* (single isolates of each, respectively). From anaerobic culture *Clostridium perfringens* 6 (13%) was identified. The antibiogram of these pathogens showed resistance to cefotaxime, cefadroxil, cefaclor, cefuroxime, ceftazidime and ceftriazone while sensitivity to meropenem, linezolid and amikacin.

**Tambekar et al** (2007b) reported the prevalence and antibiotic susceptibility pattern of MRSA in Amravati, Maharashtra state (India). A total of 150 healthcare-associated (HA) sources (doctors mobile phone and wound/pus swabs), and 160 community-associated (CA) sources (hand swab) were screened for MRSA and their antibiotic resistance pattern was performed. Out of 41 isolated strains of *S. aureus*, 77% from HA and 50% CA samples were found to be methicillin resistant. There were high prevalence of MRSA in doctor’s mobile phone (83%) and wound/pus (71%) (HA sources) than the hand swab. Almost all HA and CA MRSA strains were resistant to penicillin and penicillin V (100%) followed by cloxacillin and cephalaxin,
co-trimoxazole. About 56-67% HA and CA-MRSA strains were resistant to erythromycin, ceftazidime, lincomycin, ceftazidime, cephalexin, erythromycin and tetracycline indicating high degree of multi-resistance MRSA prevalence in the region. However, 67% strains of CA and 56% strains of HA were sensitive to vancomycin. The study showed high prevalence of MRSA in hospital setting indicating need of good control measures such as proper hand hygiene, avoiding mobile phone while wound dressing and treating patient surveillance cultures and monitoring of susceptibility patterns of MRSA may also help in arresting the spread of infections in this part of India.