

Full Length Research Paper

# A five year study on the susceptibility of isolates from various parts of the body

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In Nigeria, like most developing countries, there is little or complete lack of antibiotic prescribing policy. This results in a situation where antimicrobial agents are bought and consumed indiscriminately, thus leading to drug abuse. The ugly consequence is the development of resistance by microorganisms to these antimicrobial agents. This study seeks to determine the antibiogram of common isolates from swabs and aspirates in the University of Benin Teaching Hospital, Nigeria, in the last half a decade. The design was prospective and cross sectional. Patients attending the University of Benin Teaching Hospital clinics were used for the study. The various antimicrobial agents used in this study were amoxicillin clavulanate 30 µg, cefuroxime 30 µg, ceftazidime 5 µg, ofloxacin 5 µg, gentamicin 10 µg, amoxicillin 25 µg, erythromycin 5 µg, cloxacillin 5 µg, cotrimoxazole 5 µg, tetracycline 10 µg, and chloramphenicol 30 µg. Cultures were prepared using standard methods and incubated aerobically and anaerobically at 37°C for 48 h. Identification was by morphological characteristics and biochemical tests. The various isolates for the five-year period were *Staphylococcus aureus* 1000, *Klebsiella pneumoniae* 340, *Proteus mirabilis* 38, *Escherichia coli* 295, *Pseudomonas aeruginosa* 240, *Alcaligenes faecalis* 200, *Enterobacter aerogenes* 175, *Acinetobacter baumannii* 150, *Proteus vulgaris* 110, *Providencia stuartii* 101, *Streptococcus pneumoniae* 16, *Citrobacter freundii* 51. The isolates varied widely in their susceptibility pattern. Almost all the isolates were about 100% resistant to cloxacillin, tetracycline and cotrimoxazole. The analysis of variance (ANOVA) showed no difference in the susceptibility pattern of the isolates in the five years. However there was significant difference in the efficacy of the various antimicrobial agents and the number of isolates. This study achieved its aim of determining the microbial flora and their sensitivity pattern at the University of Benin Teaching Hospital in the last half a decade. The increasing rate of drug resistance demonstrated by the isolates particularly to cheap and frequently used antimicrobial agents raises serious concern.

**Key words:** Antibiogram, bacteria, isolates, wound, infections.

## INTRODUCTION

One of the major contributions to health care delivery in the 20<sup>th</sup> century is the discovery of potent antimicrobial agents (Wenzel and Edmond, 2001). However, the emergence of resistance of bacteria to these antibiotics raises serious concern and poses a threat to health-care delivery and a danger to the public. The incidence of resistance is multifactorial. Some organisms produce β-lactamase, an enzyme that destroys the β-lactam ring and thus renders such drugs ineffective (Jacob and

Archer, 1991). Other organisms acquire resistance to certain drugs through the transfer of plasmids, while some acquire resistance through mutation. Transfer of plasmid factor becomes prominent in chronic infection where often more than one bacterial species are involved in the infection (Agbonlahor et al., 1990).

Resistance to commonly used antimicrobials like cotrimoxazole, cloxacillin, and tetracycline has been reported in the literature (Sanghovi et al., 1999). Abundant reports exist in the literature on the susceptibility of bacterial isolates to antimicrobial agents (Bauer/Kirby, 1966; Mueller/Hinton 1941; Obasekhi-Ebor 1988; Lonk and Medeiros 1994; Jacoby and Han 1996; Lonk et al., 2002; Garau 2004; Mordi and Erah, 2006). In the last

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decade the fluoroquinolones and the cephalosporins have gained a considerable degree of importance in the treatment of bacterial infections (Mordi and Erah, 2006). Bacteria vary in their antibiogram. This study seeks to determine the susceptibility pattern of isolates from various anatomical sites of the body to the frequently used antibiotics in the University of Benin Teaching Hospital in the last half a decade.

## MATERIALS AND METHODS

### Materials

The study was conducted at the University of Benin Teaching Hospital, Benin City, Nigeria. There is a high quality bacteriology laboratory which provides referral services in the country. The hospital serves the whole of Edo State and beyond. Patients attending the University of Benin Teaching Hospital were used for the study. Demographic data were collected using a pre-form questionnaire which includes the patients name, age, and sex. Design was prospective and cross sectional.

There were a total of 4280 samples which were collected from 4280 patients. A sample was taken from each of the patients. The samples consisted of 650 higher vaginal swabs, 680 urethral swabs, 450 endocervical swabs, 600 throat swabs, 650 ear swabs, 300 aspirates, 250 eye swabs, 600 wound swabs and 100 catheter tips. There were 2480 adults. Adult males were 1300, while adult females were 1180. Male children were 1000, while female children were 800. Specimens were taken in the form of swabs from various anatomical parts of the body, namely: urethra, higher vagina, ear, eye, throat, endocervix and wounds. Aspirates and secretions were also examined. There was no particular selection order except that they were consecutively obtained.

The culture media used were chocolate and blood agar (Oxoid no cm 271). McConkey agar (oxoid no cm 7), Robison cooked meat (R C M) (oxoid no cm 81) and Nutrient agar (oxoid no cm 3).

### Cultural technique

The various agar plates were streaked aseptically with sterile wire loop, and well spaced out to form discrete colonies. Inoculated plates were incubated overnight at 37°C. Those plates which required anaerobic incubation were put in an anaerobic jar filled with hydrogen gas while others were incubated aerobically.

Conventional morphological examination was used to identify suspected pathogens. Again, standard biochemical tests were employed in the identification of gram negative bacteria (Lynette et al., 1985). Antimicrobial susceptibility testing was done on nutrients agar plates. *Streptococcus pneumoniae* was streaked on blood agar plate, because it can grow only on chocolate and blood agar plates. All the isolates were tested for their susceptibility to the various common antimicrobial agents (Mueller and Hinton, 1941). This is the standard agar disk diffusion technique.

The various antimicrobial agents used in this study include amoxicillin clavulanate 30 µg, cefuroxime 30 µg, ceftazidime 5 µg, ofloxacin 5 µg gentamicin 10 µg, amoxicillin 25 µg, erythromycin 5 µg, cloxacillin 5 µg, cotrimoxazole 5 µg, tetracycline 10 µg, and chloramphenicol 30 µg. Plates were inoculated with the isolates after which the antibiotics in a multi-disc form were laid on the agar and incubated at 37°C. The diameter of zone of inhibition was measured by standard technique (Mueller and Hinton, 1941). A standard sensitive strain *Escherichia coli* cw 3310 was included as control organism. Resistance of an isolate to a particular antibiotic is represented by R while S represents susceptibility of an organism to a particular antimicrobial agent. Results were subjected to statistical analysis (ANOVA).

## RESULTS

This study yielded twelve different bacterial species. These isolates and their total number were *Staphylococcus aureus* 1000, *Klebsiella pneumoniae* 340, *Proteus mirabilis* 300, *Escherichia coli* 295, *Pseudomonas aeruginosa*, 240 *Alcaligenes faecalis* 200, *Enterobacter aerogenes* 175, *Acinetobacter baumannii* 150, *Proteus vulgaris* 110, *Providencia stuartii* 101, *Citrobacter freundii* 51 and *S. pneumoniae* 16. Tables 1, 2, 3, 4, and 5 represent the antibiogram of the isolates for the five-year period while Table 6 showed the percentage efficacy of the antibiotics. 1302 samples yielded no growth while 2978 samples had single isolates.

From the ANOVA table the isolates varied considerably in their susceptibility to the various antimicrobial agents which showed a significant difference in activity in the five-year period. Ceftazidime had the highest efficacy of 81.16%, followed by ofloxacin, 71.618%. Nearly all the isolates (95%) were resistant to cloxacillin, cotrimoxazole and tetracycline (Table 6). There was no difference in the sensitivity pattern of an individual organism to the same antibiotic in the five-year period. The susceptibility of the isolates to amoxicillin clavulanate, cefuroxime, ceftazidime, ofloxacin and gentamicin is encouraging as they showed some promise in the effective treatment of bacterial infections.

## DISCUSSION

This study, to a large extent, shows the increasing emergence of bacterial resistance to the frequently used and cheaper antibiotics in the market. This trend poses no small threat to the public and medical practitioners. Result showed that *S. aureus* was the predominant organism. This goes to show the ubiquity of *S. aureus* on the body surface (Boyce, 1981; Doig, 1981; Kloos and Bannerman, 1995; Tuo et al., 1995). *S. aureus* has been reported to be one of the commonest causes of wound infections, burns and bone infections and the commonest gram-positive microorganism causing infections (Alausa and Menlefiore, 1978; Duguid, 1989; Thomas, 1988). The antibiogram of *S. aureus* from this study showed that the organism is strongly resistant to tetracycline and cotrimoxazole. These drugs, therefore, are now ineffective in the treatment of infections caused by *S. aureus*. However, amoxicillin, clavulanate, ceftazidime, cefuroxime, ofloxacin and gentamicin will make an important contribution in the management of infections caused by *S. aureus*.

The next predominant isolate in the study was *K. pneumoniae*. This organism belongs to the enterobacteriaceae and can cause a classic form of primary pneumoniae. It is infrequently found in the oropharynx of normal persons (1 - 6% carrier rate) (Thomas, 1988.). This organism can also cause nosocomial infections, and is among the eight most important nosocomial pathogens in hospitals (Duguid, 1989). *K. pneumoniae* is known to

**Table 1.** Antibiogram of different bacterial species from various parts of the body isolated at University of Benin Teaching Hospital, Nigeria in 2003.

Bacteria	No. of isolates	AUG	CXM	CAZ	OFX	CN	AMX	E	OB	SXT	Te	C
<i>Staphylococcus aureus</i>	200	80%	75%	75%	62.5%	62.25%	52%	42.5%	17.5%	10%	9%	30%
<i>Klebsiella pneumoniae</i>	60	74%	50%	83.5%	63.5	30%	6.7%	6.7%	Nil	Nil	18	60
<i>Proteus Mirabilis</i>	50	68%	60%	80%	60%	60%	12%	10%	Nil	12%	6%	28%
<i>Pseudomonas aeruginosa</i>	30	Nil	Nil	83.3%	66.7%	33.4%	Nil	Nil	Nil	Nil	Nil	Nil
<i>Alcaligenes faecalis</i>	20	70%	75%	90%	70%	50%	15%	15%	Nil	20%	5%	25%
<i>Enterobacter aerogenes</i>	15	33.3%	66.3%	66.7%	60%	40%	33.3%	6.7%	6.7%	6.7%	6.7%	26.7%
<i>Acinetobacter baumannii</i>	10	80	60%	80%	60%	80%	Nil	10%	10%	20%	10%	40%
<i>Proteus vulgaris</i>	10	50	30%	80%	80%	50%	10%	Nil	Nil	Nil	Nil	20%
<i>Providencia stuartii</i>	6	50%	33.3%	66.7%	66.7%	16.7%	16.7%	16.7%	Nil	Nil	16.7%	16.7%
<i>Streptococcus pneumoniae</i>	1	100%	100%	100%	100%	Nil	100%	100%	Nil	Nil	Nil	100%
<i>Citrobacter freundii</i>	1	100%	100%	100%	100%	100%	100%	100%	Nil	Nil	Nil	100%
<i>Escherichia coli</i>	3	80	57.1%	80%	71%	25.6%	11.4	11.4	Nil	2.8%	Nil	31%

AUG = Amoxicillin Clavulanate (30 µg), CN = Gentamycin (10 µg), SXT = Cotrimoxazole (5 µg), CXM = Cefuroxime (30 µg), AMX = Amoxicillin (25 µg), TE = Tetracycline (10 µg), CAZ = Ceftazidime (5 µg), E = Erythromycin (5 µg), C = Chloramphenicol (30 µg), OFX = Ofloxacin (5 µg), and OB = Cloxacillin (5 µg).

Values represent the percentage of isolates susceptible to the indicated antibiotic.

be resistant to penicillin. Of particular concern is the recent emergence of *Klebsiella* strain that possesses plasmids that mediate resistance to extended spectrum of  $\beta$ -lactam drugs (ESBLs) (Thomas, 1988; Sofala, 1982). A unique feature of ESBLs is their ability to escape detection with most of the commonly used susceptibility tests and the resultant concern is that organisms, which possess ESBL, are reported to be susceptible to antibiotics to which they are actually resistant (Renold, 1982; Podschun and Ullman, 1998; Livermore, 1995; Jarlier et al., 1988; Meyer et al., 1993). In this study, ceftazidime, amoxicillin clavulanate, ofloxacin and cefuroxime make important contribution to the management of infections caused by *K. pneumoniae*. On the other hand cloxacillin, tetracycline, cotrimoxazole, erythromycin, amoxicillin, chloramphenicol and gentamicin are not effective for the management of infections caused by *K. pneumoniae*.

The next predominant isolate in this study was *P. mirabilis*. This organism is indole negative and is most frequently isolated from clinical specimen. It swarms on

solid media, which possess electrolyte. It is differentiated from *P. vulgaris* by its susceptibility to chloramphenicol to which *P. vulgaris* is resistant and indole negative (Meyer et al., 1993). In this study *P. mirabilis* showed a considerable resistance to cloxacillin, tetracycline, cotrimoxazole, amoxicillin, and chloramphenicol. These antibiotics will therefore not be effective in the management of any infection caused by *P. mirabilis*. However, it showed considerable susceptibility to ceftazidime, amoxicillin clavulanate, cefuroxime, gentamicin and ofloxacin. The susceptibility of *P. mirabilis* to ceftazidime, cefuroxime, amoxicillin and clavulanate in this study agrees with previous work in the literature. *P. mirabilis* has been shown to be susceptible to the penicillins and cephalosporins (Hickman et al., 1982; Bodey et al., 1983). However the susceptibility of *P. mirabilis* in this study to chloramphenicol was contrary to the observation in the literature (Hickman et al., 1982). In this study, the susceptibility to chloramphenicol was only 28% whereas earlier study claimed chloramphenicol to be the drug of choice for the management of infections caused by *P.*

**Table 2.** Antibiogram of different bacterial species from various parts of the body isolated at University of Benin Teaching Hospital, Nigeria in 2004.

Bacteria	No. of isolates	AUG	CXM	CAZ	OFX	CN	AMX	E	OB	SXT	Te	C
<i>Staphylococcus aerus</i>	210	80%	75%	62%	62%	62%	52%	42%	17%	10%	9%	30%
<i>Klebsiella pneumoniae</i>	60	74%	50%	83%	63%	30%	7%	7%	Nil	Nil	Nil	4%
<i>Proteus Mirabilis</i>	60	68%	60%	80%	60%	60%	12%	10%	Nil	12%	6%	28%
<i>Escherichia coli</i>	50	80%	57%	80%	71%	25%	11%	11%	Nil	2.8%	Nil	31
<i>Pseudomonas aeruginosa</i>	40	Nil	Nil	84%	67%	33%	Nil	Nil	Nil	Nil	Nil	Nil
<i>Alkaligenes faecalis</i>	40	70%	75%	90%	70%	50%	15%	15%	Nil	20%	5%	25%
<i>Enterobacter aerogenes</i>	30	33%	66%	66%	60%	40%	33%	6%	6%	7%	7%	26%
<i>Acinetobacter baumannii</i>	20	80%	60%	80%	60%	80%	Nil	10	10	20	10%	40%
<i>Protens vulgaris</i>	10	50%	30%	80%	80%	50%	10%	Nil	Nil	Nil	Nil	20%
<i>Providencia stuartii</i>	10	50%	33%	66%	66%	16%	16%	16%	Nil	Nil	16%	16%
<i>Streptococcus pneumoniae</i>	2	100%	100%	100%	100%	100%	100%	100%	Nil	Nil	Nil	100%
<i>Citrobacter freundii</i>	20	100%	100%	100%	100%	100%	100%	100	Nil	Nil	Nil	100%

AUG = Amoxicillin Clavulanate (30 µg), CN = Gentamycin (10 µg), SXT = Cotrimoxazole (5 µg), CXM = Cefuroxime (30 µg), AMX = Amoxicillin (25 µg), TE = Tetracycline (10 µg), CAZ = Ceftazidime (5 µg), E = Erythromycin (5 µg), C = Chloramphenicol (30 µg), OFX = Ofloxacin (5 µg), and OB = Cloxacillin (5 µg).

Values represent the percentage of isolates susceptible to the indicated antibiotic.

**Table 3.** Antibiogram of different bacterial species from various parts of the body isolated at University of Benin Teaching Hospital, Nigeria in 2005.

Bacteria	No. of isolates	AUG	CXM	CAZ	OFX	CN	AMX	E	OB	SXT	Te	C
<i>Staphylococcus aerus</i>	190	80%	75%	62%	62%	62%	52%	42%	17%	10%	9%	30%
<i>Klebsiella pneumoniae</i>	70	74%	50%	63%	63%	30%	7%	7%	Nil	Nil	Nil	4%
<i>Proteus Mirabilis</i>	50	68%	60%	60%	60%	60%	12%	10%	Nil	12%	6%	28%
<i>Escherichia coli</i>	60	80%	57%	71%	71%	25%	11%	11%	Nil	3%	Nil	31
<i>Pseudomonas aeruginosa</i>	50	Nil	Nil	67%	67%	33%	Nil	Nil	Nil	Nil	Nil	Nil
<i>Alkaligenes faecalis</i>	40	70%	75%	70%	70%	50%	15%	15%	Nil	20%	5%	25%
<i>Enterobacter aerogenes</i>	40	33%	66%	60%	60%	40%	33%	6%	6%	7%	7%	26%
<i>Acinetobacter baumannii</i>	30	80%	60%	60%	60%	80%	Nil	10	10	20	10%	40%

**Table 3.** Contd.

<i>Protens vulgaris</i>	30	50%	30%	80%	80%	50%	10%	Nil	Nil	Nil	Nil	20%
<i>Providencia stuartii</i>	35	50%	33%	66%	66%	16%	16%	16%	Nil	Nil	16%	16%
<i>Streptococcus pneumoniae</i>	4	100%	100%	100%	100%	100%	100%	100%	Nil	Nil	Nil	100%

AUG = Amoxicillin Clavulanate (30 µg), CN = Gentamycin (10 µg), SXT = Cotrimoxazole (5 µg), CXM = Cefuroxime (30 µg), AMX = Amoxicillin (25 µg), TE = Tetracycline (10 µg), CAZ = Ceftazidime (5 µg), E = Erythromycin (5 µg), C = Chloramphenicol (30 µg), OFX = Ofloxacin (5 µg), and OB = Cloxacillin (5 µg).

Values represent the percentage of isolates susceptible to the indicated antibiotic.

**Table 4.** Antibiogram of different bacterial species from various parts of the body isolated at University of Benin Teaching Hospital, Nigeria in 2006.

Bacteria	No. of isolates	AUG	CXM	CAZ	OFX	CN	AMX	E	OB	SXT	Te	C
<i>Staphylococcus aerus</i>	220	80%	75%	62.2%	62%	62%	52%	42%	17%	10%	9%	30%
<i>Klebsiella pneumoniae</i>	80	74%	50%	83%	63%	30%	7%	7%	Nil	Nil	Nil	4%
<i>Proteus Mirabilis</i>	80	68%	60%	80%	60%	60%	12%	10%	Nil	12%	6%	28%
<i>Pseudomonas aeruginosa</i>	60	80%	Nil	84%	67%	33%	Nil	Nil	Nil	Nil	Nil	Nil
<i>Alkaligenes faecalis</i>	50	Nil	75%	90%	70%	50%	15%	15%	Nil	20%	5%	25%
<i>Enterobacter aerogenes</i>	50	70%	66%	66%	60%	40%	33%	6%	6	7%	7%	26%
<i>Acinetobacter baumannii</i>	50	33%	60%	80%	60%	80%	Nil	10%	10%	20%	10%	40%
<i>Protens vulgaris</i>	40	80%	30%	80%	80%	50%	10%	Nil	Nil	Nil	Nil	20%
<i>Providencia stuartii</i>	30	50%	33%	66%	66%	16%	16%	16%	nil	nil	16%	16%
<i>Streptococcus pneumoniae</i>	4	50%	100%	100%	100%	100%	100%	100%	Nil	Nil	Nil	100%
<i>Citrobacter freundii</i>	10	100%	100%	100%	100%	100%	100%	100%	Nil	Nil	Nil	100%
<i>Escherichia coli</i>	70	100%	57%	80%	71%	100%	11%	11%	Nil	3	Nil	31%

AUG = Amoxicillin Clavulanate (30 µg), CN = Gentamycin (10 µg), SXT = Cotrimoxazole (5 µg), CXM = Cefuroxime (30 µg), AMX = Amoxicillin (25 µg), TE = Tetracycline (10 µg), CAZ = Ceftazidime (5 µg), E = Erythromycin (5 µg), C = Chloramphenicol (30 µg), OFX = Ofloxacin (5 µg), and OB = Cloxacillin (5 µg).

Values represent the percentage of isolates susceptible to the indicated antibiotic.

*mirabilis* (Hickman et al., 1982). This development of resistance may have resulted from resistant plasmid acquisition or mutation.

The next predominant isolate was *P. aeruginosa* and it is the most common pseudomonad causing human infections. The organism is known to be prevalent among patients with burns, wounds, cystic fibrosis, acute leukaemia, intravenous drug addition, external ear infection, indwelling catheters and weeping cutaneous wounds

(Labarca et al., 1998). The susceptibility pattern reported in the literature conforms with the pattern in this study. The organism is 100% resistant to all the drugs except ceftaxidime, ofloxacin, and gentamycin. Ceftaxidime is the only cephalosporin that the organism is susceptible to. It shows some degree of susceptibility to the quinolones. Its susceptibility to the aminoglycosides in this study is not encouraging. *P. aeruginosa* has been reported in the literature as a cause of nosocomial infection

**Table 5.** Antibiogram of different bacterial species from various parts of the body isolated at University of Benin Teaching Hospital, Nigeria in 2007.

Bacteria	No. of isolates	AUG	CXM	CAZ	OFX	CN	AMX	E	OB	SXT	Te	C
<i>Staphylococcus aerus</i>	180	80%	75%	62.2%	62.2%	62%	52%	42%	17%	10%	9%	30%
<i>Klebsiella pneumoniae</i>	70	74%	50%	83%	63%	30%	7%	7%	Nil	Nil	Nil	4%
<i>Proteus mirabilis</i>	60	68%	60%	80%	60%	60%	12%	10%	Nil	12%	6%	28%
<i>Escherichia coli</i>	80	80%	57%	80%	71%	25%	11%	11%	Nil	2.8	Nil	31
<i>Pseudomonas aeruginosa</i>	60	Nil	Nil	84%	67%	33%	Nil	Nil	Nil	Nil	Nil	Nil
<i>Alcaligenes faecalis</i>	50	70%	75%	90%	70%	50%	15%	15%	Nil	20%	5%	25%
<i>Enterobacter aerogenes</i>	40	33%	66%	66%	60%	40%	33%	6%	6%	7%	7%	26%
<i>Acinetobacter baumannii</i>	40	80%	60%	80%	60%	80%	Nil	10	10	20	10	40%
<i>Proteus vulgaris</i>	20	50%	30%	80%	80%	50%	10%	Nil	Nil	Nil	Nil	20%
<i>Providencia stuartii</i>	20	50%	33%	66%	66%	16%	16%	16%	Nil	Nil	16	16%
<i>Streptococcus pneumoniae</i>	5	100%	100%	100%	100%	100%	100%	100%	Nil	Nil	Nil	100%
<i>Citrobacter freundii</i>	10	100%	100%	100%	100%	100%	100%	100%	Nil	Nil	Nil	100%

AUG = Amoxicillin Clavulanate (30 µg), CN = Gentamycin (10 µg), SXT = Cotrimoxazole (5 µg), CXM = Cefuroxime (30 µg), AMX = Amoxicillin (25 µg), TE = Tetracycline (10 µg), CAZ = Ceftazidime (5 µg), E = Erythromycin (5 µg), C = Chloramphenicol (30 µg), OFX = Ofloxacin (5 µg), and OB = Cloxacillin (5 µg).

Values represent the percentage of isolates susceptible to the indicated antibiotic.

(Livermore, 2002). It is also reported to have a mechanism for antimicrobial resistance (Gales et al., 2001). Infections which are caused by the Pseudomonads can be difficult to manage since the organism is susceptible to relatively a narrow spectrum of antibiotics which includes the carboxypenicillin (carbenicillin), tricarcillin, ureidopenicillins (mezlocillin, piperacillin) the anti pseudomonad cephalosporins (ceftazidime), monobactams (aztreonam), carbapenems (imipenems, meropenem), quinolones (ofloxacin, ciprofloxacin, and levofloxacin), and the aminoglycosides (gentamycin, tobramycin, and amikacin). Almost all strains are resistant to other penicillins, cephalosporins including ampicillin, cefuroxime and cefotaxime (Macfarlane et al., 1991). *P. aeruginosa* has the capacity to carry multi-resistant plasmid and this has led to the emergence of some *P. aeruginosa* strains that are resistant to all available and reliable antibiotics (Gales et al., 2001).

The next isolate is *Alcaligenes faecalis* and this organism is the most frequently isolated member of the alcaligenaceae in clinical laboratory. *A. faecalis* lives in the soil and water and has been isolated from many

types of clinical specimens. Results showed that it was moderately sensitive to the penicillins (amoxicillin, clavulanate), the cephalosporin (cefuroxime and ceftazidime), the quinolones (ofloxacin) and moderately susceptible to the aminoglycoside (gentamycin). The organism demonstrated a very strong resistance to amoxicillin, erythromycin, cloxacillin, cotrimoxazole, tetracycline, and chloramphenicol. These drugs, therefore, cannot be used for the treatment of any infection caused by this organism.

The next isolate was *E. aerogenes*. This organism has the general characteristics of *Klebsiella* species but can be differentiated from most *Klebsiella* species by being motile and ornithine positive. *E. aerogenes* is frequently encountered in clinical specimens. It is widely distributed in water, sewage, soil and vegetables. It is important that this organism be controlled since the sources of infection are wide. It exists as part of the commensal enteric flora and is believed not to cause diarrhoea. It is associated with a variety of opportunistic infections involving the urinary tract, respiratory tract, and cutaneous wounds and occasionally causes septicemia and meningitis

**Table 6.** Susceptibility of the different bacterial species (%) from various parts of the body isolated at University of Benin Teaching Hospital, Nigeria.

Antibiotic	<i>A. baumannii</i>	<i>A. faecalis</i>	<i>C. freundii</i>	<i>E. aerogenesi</i>	<i>E. coli</i>	<i>K. pneumonia</i>	<i>P. mirabilis</i>	<i>P. vulgaris</i>	<i>P. stuartii</i>	<i>P. aeruginosa</i>	<i>S. aureus</i>	<i>S. pneumoniae</i>	X*
AMX	0	15	100	33.06	11.08	6.94	12	10	16.14	0	52	100	29.68G
Aug	80	70	100	33.06	80	74	68	50	50	0	80	100	65.42C
C	40	25	100	26.14	31	3.9	28	16.4	16.14	0	24.6	100	34.26F
Caz	80	90	100	66.14	80	83.1	80	80	66.14	83.86	64.68	100	81.16A
CN	80	50	100	40	25.12	30	60	50	16.14	33.08	62.05	80	52.2E
CXM	60	75	100	66.14	57.02	50	60	30	33.06	0	75	100	58.85D
E	10	15	100	6.14	11.08	6.94	16	0	16.14	0	42.1	100	26.95H
OB	10	0	0	6.14	0	0	0	0	0	0	17.1	0	2.77K
Ofx	60	70	100	60	71	63.1	60	80	66.14	66.94	62.09	100	71.61B
SXT	20	20	0	6.94	2.88	0	12	0	0	0	10	0	5.99I
Te	10	5	0	6.94	0	0	6	0	16.14	0	9	0	4.42J
X**	40.91D	39.55D	72.73A	31.88F	35.56	28.91G	36.55E	28.76G	26.91	16.72H	45.33C	70.91B	X

Means with different alphabetic remarks are significantly different at 5% probability level.

X\*: Vertical mean comparison only.

X\*\*: Horizontal mean comparison only.

AUG = Amoxicillin Clavulanate (30 µg), CN = Gentamycin (10 µg), SXT = Cotrimoxazole (5 µg), CXM = Cefuroxime (30 µg), AMX = Amoxicillin (25 µg), TE = Tetracycline (10 µg), CAZ = Ceftazidime (5 µg), E = Erythromycin (5 µg), C = Chloramphenicol (30 µg), OFX = Ofloxacin (5 µg), and OB = Cloxacillin (5 µg).

Values represent the percentage of isolates susceptible to the indicated antibiotic

(Parodi et al., 2003). The organism was moderately susceptible to the cephalosporins (cefuroxime and ceftazidime), and the quinolones (ofloxacin). It is poorly susceptible to the penicillins (amoxicillin clavulanate), and the aminoglycoside (gentamicin). It is strongly resistant to erythromycin, cloxacillin, cotrimoxazole, tetracycline and chloramphenicol. There are reports in the literature that *Enterobacter* species and certain other members of enterobacteriaceae carry a gene for chromosomally encoded  $\beta$ -lactamase that can be induced by certain antibiotics, amino acids or body fluids (Huber and

Thomas, 1994; Livermore, 1995). Unlike plasmid-mediated  $\beta$ -lactamase, these enzymes are not normally expressed. It is only under the influence of an inducer or following mutation that the genes become activated and the enzyme expressed (Huber and Thomas, 1994). It is of considerable concern that microbes which carry genes for inducible  $\beta$ -lactamase show false susceptibility if tested in the uninduced state. The medical implication of this phenomenon is the production of unreliable or false antibiogram, and this is a major cause of treatment failures (Huber and Thomas, 1994).

*E. coli* is one of the common bacterial isolates in this study. *S. aureus*, *K. pneumoniae*, *P. mirabilis* and *E. coli* are the predominant bacterial isolates and this observation is in accord with reports from Sudan (Yagi, 1990) and the Solomon's island (Eason et al., 1996). The antibiogram of the *E. coli* isolate from this study shares some similarity with that obtained from a similar study in the literature (Dawit et al., 2001). However the *E. coli* in this study showed strong resistance to amino glycoside (gentamicin).

An important observation in this study is the antibiogram of the enterobacteriaceae observed in

this study. They were significantly susceptible to the third generation antibiotics (Dawit et al., 2001; Ling et al., 2001; Ling et al., 2003). They are strongly resistant to amoxicillin, erythromycin, cloxacillin, cotrimoxazole and chloramphenicol. This same resistance has also been reported in the literature (Ling et al., 2001). *Proteus* species, *Klebsiella* species and *Escherichia* species which were reported to be 88% sensitive to gentamycin in the literature (Dawit et al., 2001) were very strongly resistant to the drug in this study.

The other isolates in this study are *Acinetobacter baumannii*, *P. vulgaris*, *Providencia stuartii*, *S. pneumoniae* and *Citrobacter freundii* which formed an insignificant percentage of the total isolates. *A. baumannii*, *C. freundii* and *P. stuartii*, except for causing urinary tract infection have been cited for the cause of several nosocomial outbreaks (Penner, 1984). Infections caused by these organisms are uncommon and limited to isolated case reports. This explains the scanty isolation of these organisms in this study.

There is one common observation in this study. All the isolates showed very strong resistance to cloxacillin, cotrimoxazole and tetracycline, and this observation has also been reported in the literature (Sanghovi et al., 1999). The cause of resistance to these drugs may not be unconnected to drug abuse. These are the most frequently used drugs in the community. They are cheap and easily available. The drugs are purchased without prescription and consumed indiscriminately. None of these drugs can be used for the successful treatment of any bacterial infections. It is pertinent to know that resistance is a local problem because elsewhere in the globe the drugs may still be very potent.

## Conclusion

The high rate of antibiotic resistance, especially to the cheap and frequently used antimicrobial agents, poses a serious problem to clinicians at the University of Benin Teaching Hospital. The speed of emergence of these antibiotic resistant organisms is not matched by the same rate of development of new antimicrobial agents. Patients who have serious bacterial infections will soon no longer be treatable with the currently available antimicrobials. There should be strict management of antibiotic policies and surveillance programmes for multiple resistant organisms. There is need for infection control programmes which should be implemented and continuously audited (Eliot and Lambert, 1999). The pharmaceutical industries must, as a matter of urgency, respond to these clinical challenges by bringing forward a stream of new agents with antimicrobial activity against resistant bacteria.

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