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Antimicrobial Resistance in 6 Malaysian General Hospitals

Y M Cheong, MRCPath*
V K E Lim, FRCPath**
M Jegathesan, FRCPath*
A B Suleiman, FRACP***
* *Institute for Medical Research, 50588 Kuala Lumpur*
** *Department of Medical Microbiology & Immunology, Faculty of Medicine, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur*
*** *Ministry of Health, Malaysia, Jalan Cenderasari, 50590 Kuala Lumpur*

Summary

Knowledge of local antimicrobial resistance patterns of bacteria is a valuable guide to empirical antimicrobial therapy. This paper reports the resistance patterns of more than 36,000 bacteria isolated between August 1991 and July 1992 in six Malaysian hospitals and discusses the implications of the results. A customised menu driven software programme was developed to analyse the results. Generally, resistance to the commonly used antibiotics like ampicillin, cloxacillin, cephalosporins, gentamicin, cotrimoxazole and tetracycline was high. Some differences in resistance rate amongst the six hospitals were also noted. Continuous surveillance of antimicrobial resistance in hospitals is encouraged for the effective control of the emergence of antimicrobial resistance.

Key Words: Antimicrobial resistance patterns

Introduction

Knowledge of the local antimicrobial resistance patterns of bacteria is indeed a valuable guide to empirical antimicrobial therapy and the formulation of antibiotic guidelines. It is also an important prerequisite for the control of the emergence of antimicrobial resistance in hospitals which tend to provide an excellent environment for the emergence and spread of resistant bacteria[1]. A national health system research project on the control of nosocomial infections was conducted in six Malaysian general hospitals from 1990 to 1992. One of the objectives of this study was to monitor the antimicrobial resistance patterns of bacteria isolated from patients in the hospitals. This paper reports the resistance patterns of more than 36,000 bacteria isolated between August 1991 to July 1992 in the study hospitals and discusses the implications of the results.

Materials and Methods

Bacterial isolates

The bacteria studied were clinical isolates from specimens submitted to the laboratories in the six general hospitals namely Malacca, Johore Bahru, Kuantan, Kuala Terengganu, Alor Setar and Kuching hospitals between August 1991 to July 1992. They were identified according to standard methods and for the *Enterobacteriaceae* they were usually identified up to the genus level only.

Antimicrobial susceptibility testing

Antimicrobial susceptibilities were determined by the comparative technique[2]. Although a recommended list of antibiotics to be tested against the different groups of bacteria was given to each laboratory, the individual laboratory was free to choose the

antibiotics to be tested. Hence certain antibiotics were only tested in the laboratories where the antibiotics were used in the hospital and not in another. Second line antimicrobials like amikacin and the third generation cephalosporins were only tested when there was resistance to the first line drugs. All the laboratories were issued the following control strains: *S. aureus* NCTC 6571 for staphylococci and streptococci, *Escherichia coli* NCTC 10418 for gram negative bacilli, *Pseudomonas aeruginosa* NCTC 10662 for *Pseudomonas* spp and *H. influenzae* NCTC 11931 for *Haemophilus* spp. These laboratories also participated in a National Quality Control Programme conducted by the Institute for Medical Research (IMR) on identification and antimicrobial susceptibility testing whereby unknown cultures were sent three times a year to all government laboratories.

Analysis of results

As the laboratories do not have a computer, the results were first recorded in a form in codes ready for entry into a computer. These forms were then sent to the IMR every week and the data entered into a 386 IBM compatible personal computer. A customised menu driven programme was developed by a commercial firm using the Paradox PAL language (Borland International, 1988). This programme had the following features:

a) Data entry programme which could recognise duplicate organisms from the same patient and same site.

b) Daily listing of antimicrobial susceptibility pattern of bacteria sorted out by species and according to wards.

c) Age distribution of cases from which the bacteria were isolated.

d) Frequency distribution of bacteria isolated in the hospital and according to type of specimens.

e) The antimicrobial susceptibility pattern of bacteria sorted by genus or species from all types of specimens and different types of specimens.

f) Graphics in the form of bar charts to show the percentage of different groups of bacteria resistant to specified antimicrobials.

Results

Bacterial isolates

From August 1991 to July 1992, antimicrobial susceptibilities were determined for 36,343 bacteria isolated from clinical specimens in the laboratories of the six hospitals. The breakdown of the number of isolates from the six hospitals is shown in Table I. The frequency distribution of the different bacterial isolates is shown in Table II. *E. coli, Klebsiella* spp, and *S. aureus* were the most common bacteria isolated, constituting 57% of all isolates. The types of specimens from which these bacteria were isolated are shown in Table III. Wound/pus (32%) and urine specimens (21%) were the most common samples yielding positive isolates. The majority of the isolates came from the 21 to 40 year age group (29%) and neonatal age group (15%).

Antibiotic Resistance Patterns

The resistance patterns of the gram positive bacteria from all the six hospitals are shown in Table IV. The results for the *Enterococcus* spp were not included as the interpretation of the results in some of the laboratories were incorrect. There was some variation in the resistance patterns between the six hospitals, for example the percentage of methicillin resistant *S. aureus* (MRSA) in Kuantan and Kuching hospitals was 6.7% whereas in Johore Bahru it was 31.7% The few strains of Group A and Group B streptococci that were

Table I
Number of bacterial isolates tested in the six hospitals
(Aug 91 – July 92)

General Hospitals	Nos. tested
Alor Setar	4663
Johor Bahru	8011
Kuantan	5076
Kuching	6644
Melaka	6609
Kuala Terengganu	5340
Total	36343

reported to be resistant to penicillin were not confirmed at the IMR laboratory.

Table V shows the resistance pattern of some of the more common gram negative bacilli encountered in the hospitals. Resistance to ampicillin, cotrimoxazole and tetracycline were generally high and is consistently similar in all the six hospitals. However resistance to gentamicin amongst the *Enterobacteriaceae* was very much lower in Kuala Terengganu hospital than in other hospitals eg. percentage of *E. coli* resistant to gentamicin was 3.6%, *Klebsiella* spp 7.4% and *Enterobacter* spp 8.5% compared to the average percentages of 10.2%, 19.5% and 22.5% respectively. However these differences were not so apparent amongst the *Pseudomonas aeruginosa*, although the resistance rate in Kuala Terengganu hospital was still the lowest amongst the six hospitals (20.2% compared to the average of 28.1%).

It was not possible to compare the resistance to the cephalosporins and the newer antibiotics as these were second line drugs, and some laboratories tested them regularly while others did not.

Tables VI-X show the resistance rates of the five most common bacteria isolated from blood, urine, pus and sputum specimens. Generally the resistance rates of these bacteria to the antimicrobials were practically

Table II
Frequency distribution of the bacteria isolated from all the six hospitals
(Aug 91 – July 92)

Bacteria	No.	%
Escherichia coli	7506	20.7
Klebsiella spp	6332	17.4
Staphylococcus aureus	6723	18.5
Acinetobacter spp	3033	8.4
Pseudomonas aeruginosa	3206	8.8
Enterobacter spp	1760	4.8
Proteus spp	1652	4.5
Coagulase neg. *Staphylococcus*	1308	3.6
Pseudomonas spp	897	2.5
Group A *Streptococcus*	563	1.5
Group B *Streptococcus*	360	1.0
Citrobacter spp	531	1.5
Serratia spp	384	1.1
Salmonella spp	257	0.7
Morganella morganii	242	0.7
Enterococcus spp	222	0.6
Streptococcus pneumoniae	133	0.4
Salmonella Typhi	146	0.4
β-haemolytic Strep (others)	317	0.9
Neisseria gonorrhoeae	114	0.2
Haemophilus influenzae	39	0.1
Others	618	1.7
Total	36343	100.0%

Table III
Frequency distribution of specimens of all six hospitals
(Aug 91 – July 92)

Specimens	No.	%
Wound/Pus	11645	32.1
Urine	7461	20.5
Genital specimens	3000	8.2
Blood	2440	6.7
Throat swab	1497	4.1
Eye swab	1418	3.9
Sputum	1686	4.6
Ear swab	1157	3.1
Cathether tips (other than urinary catheter tips)	1259	3.5
Umbilical swab	626	1.7
Nasal swab	507	1.4
Endotracheal tube swab	923	2.5
Peritoneal dialysate	650	1.8
Tracheal aspirate	856	2.4
Stool	438	1.2
Ascitic fluid	118	0.3
Gastric fluid	158	0.4
Tissue	35	0.1
Pleural fluid	87	0.2
Bile	60	0.2
Cerebrospinal fluid	87	0.2
Chest tube	69	0.2
Pericardial fluid	149	0.4
Others	17	0.1
Total	36343	100%

similar irrespective of the type of specimens from which they were isolated, with the exception of *Klebsiella pneumoniae* from sputum specimens. The percentages of *K. pneumoniae* resistant to the cephalosporins and aminoglycosides isolated from sputum were rather low compared to those isolated from blood, urine and pus (Table VIII).

Discussion

The antimicrobial resistance patterns of the various bacteria described here refer to clinical isolates encountered in a hospital setting. This study does not differentiate between the antimicrobial resistance patterns of bacteria in community acquired and nosocomial infections, neither does it cover only the clinically significant isolates. The resistance rates described here are only based on *in vitro* tests. It must also be noted that in order to achieve a confidence level of 90%, approximately 150 samples need to be tested. Most of the bacterial groups tested comprised more than 150 isolates. The resistance rates of a few bacterial groups like *H. influenzae* were not reported for this reason.

Penicillin has remained the antibiotic of choice for the treatment of streptococcal and pneumococcal infections. In this study none of the 127 strains of pneumococcal strains tested were resistant to penicillin. In an earlier study done in 1984 amongst isolates from Malaysian children with acute respiratory infections, 2% of the pneumococcal strains were moderately resistant to penicillin[3]. Penicillin resistance of 1-2% in group A and B streptococci was not confirmed by the IMR. Instructions were given at the beginning of the study that with rare occurrences such as these, the bacteria should be sent to the IMR for confirmation with the dilution test. The few strains that were received, were usually found to be wrongly identified or actually susceptible to penicillin on retesting. Therefore these results could be laboratory errors. It was not data entry error as the original forms were checked. It was not surprising to note that more than 75% of the *S. aureus* were resistant to penicillin.

Ampicillin, a semisynthetic penicillin, is one of the most commonly prescribed antibiotic in general practice. It is frequently used for simple urinary tract infections (UTI). In this study, *E. coli* was the commonest cause of UTI and 46% of these strains were resistant to ampicillin, while 60% of *E. coli* isolated from all specimens were resistant to ampicillin. Therefore in a hospital setting, an alternative to ampicillin for the empirical treatment of UTI has to be considered.

Enterobacter, Klebsiella, Serratia, Citrobacter and *Providencia* spp are nearly always ampicillin resistant[4]. This is also supported by this study where over 90% of the *Klebsiella* and 80% of the *Enterobacter* spp were resistant to ampicillin.

To increase the antibacterial spectrum of penicillin derivatives, two β-lactamase inhibitors, clavulanic acid and sulbactam have been added to amoxycillin and ampicillin respectively. From our study, this had reduced the resistance rate of *E. coli* to ampicillin from 60% to 12-21%. However, the reduction was not as evident with the *Enterobacter* spp. probably because this organism commonly produces the Richmond-Sykes Class I β-lactamases, which are not inhibited by these two β-lactamase-inhibitors[5].

Methicillin is the first penicillinase resistant semi-synthetic penicillin, now used mainly for sensitivity testing of staphylococci, and the results obtained in general, apply to all penicillinase-resistant penicillins like cloxacillin, flucloxacillin and nafcillin and also the cephalosporins. The overall prevalence rate of methicillin resistant *S. aureus* (MRSA) was 19% which was quite comparable to the result of and earlier report in 1988[6].

The drug of choice for the treatment of serious MRSA infections is vancomycin[7]. In this study, 4 out of 854 strains had been reported to be resistant to vancomycin *in vitro*. Again this was not confirmed by the IMR laboratory and it could have been technical error. Alternative drugs like a combination of fusidic acid and rifampicin had been reported to be effective and in this study the resistance rates to these drugs were about 4% (Table IV).

Imipenem and aztreonam are new beta-lactam drugs which are not readily available in the government hospitals. The resistance rates obtained in this study

Table IV
Percentage of gram positive bacteria resistant to antimicrobials in six hospitals
(Aug. 91 – July 92)

Bacteria / Antimicrobials	*S. aureus*	MRSA	*S. pneumoniae*	Group A Strept.	Group B Strept.
Penicillin	76.6 (6642)	98.8 (1244)	0.0 (127)	*1.1 (534)	*1.4 (348)
Methicillin	19.4 (6563)	100 (1274)	–	–	–
Erythromycin	26.0 (6404)	85.7 (1207)	6.4 (109)	3.9 (486)	7.6 (316)
Fusidic acid	3.1 (6257)	4.4 (1148)	–	–	–
Cotrimoxazole	24.6 (4091)	82.6 (798)	–	–	–
Tetracycline	34.3 (3856)	90.7 (568)	18.2 (110)	23.8 (483)	60.6 (315)
Gentamicin	–	88.8 (1040)	–	–	–
Amikacin	–	55.0 (753)	–	–	–
Netilmicin	–	46.9 (706)	–	–	–
Rifampicin	–	3.7 (645)	–	–	–
Perfloxacin	–	5.6 (484)	–	–	–
Vancomycin	–	0.5 (854)	–	–	–

MRSA : Methicillin resistant S. aureus
( ) : no. tested
** : Results not confirmed*

would be reflective of the situation before a drug is widely used. The resistance rate of *E. coli*, *Klebsiella* spp, *Enterobacter* spp, *Proteus* spp, *Acinetobacter* spp and *Pseudomonas aeruginosa* to imipenem varies from 0.5 to 3.7% (Table V). Resistance to aztreonam, a monobactam which is specific for gram negative sepsis was much higher, i.e. from 4.2% to 15.8%.

The cephalosporins tested by most hospitals were cephalexin, cefuroxime, cefoperazone, cefotaxime, ceftazidime and occasionally ceftriaxone. Most of the time the third generation cephalosporins were only tested when the bacteria were resistant to the first line drugs. Comparing the resistance rates of the *Enterobacteriaceae* to the three most commonly tested

Table V
Percentage of gram negative bacteria resistant to antimicrobials in six hospitals
(Aug. 91 – July 92)

Bacteria / Antimicrobials	*E. coli*	*Klebsiella* spp.	*Enterobacter* spp.	*Proteus*	*Ps. aeruginosa*	*Acinetobacter* spp.
Ampicillin	60.1 (7065)	93.2 (5499)	82.5 (1637)	52.7 (1572)	–	78.1 (2763)
Cotrimoxazole	35.5 (7025)	28.1 (5767)	33.2 (1642)	40.1 (1529)	–	46.4 (2797)
Tetracycline	49.7 (4264)	27.2 (3343)	42.0 (940)	–	–	43.3 (1382)
Cephalexin	17.5 (3208)	22.3 (2378)	70.5 (655)	58.1 (609)	–	81.8 (1117)
Cefuroxime	6.9 (5677)	14.7 (4973)	25.8 (1372)	18.0 (1240)	–	45.5 (2573)
Cefoperazone	8.0 (6201)	12.8 (5323)	15.3 (1356)	6.3 (1372)	13.6 (1932)	43.9 (2522)
Cefotaxime	3.8 (2713)	8.5 (2253)	11.2 (538)	3.8 (558)	42.2 (1299)	21.5 (1065)
Ceftazidime	5.5 (4923)	16.6 (4102)	15.7 (1204)	2.8 (1105)	6.8 (3086)	16.4 (2049)
Ceftriaxone	3.3 (877)	10.7 (810)	12.4 (121)	2.8 (285)	42.0 (69)	23.0 (278)
Gentamicin	10.2 (6569)	19.5 (5584)	22.5 (1550)	13.9 (1502)	28.1 (2933)	43.5 (2558)
Netilmicin	7.6 (4152)	16.3 (3656)	18.2 (918)	7.9 (906)	24.0 (2724)	22.4 (1745)
Amikacin	2.8 (5640)	5.8 (4937)	7.2 (1433)	1.9 (1286)	6.2 (3052)	18.9 (2619)
Nitrofurantoin	4.7 (2697)	12.4 (1035)	22.7 (269)	–	–	78.4 (402)
Norfloxacin	0.7 (914)	0.9 (847)	1.7 (118)	1.6 (256)	–	10.5 (275)
Perfloxacin	0.8 (3731)	1.2 (2659)	1.2 (911)	1.5 (647)	11.8 (1285)	5.0 (1474)
Imipenem	0.6 (3817)	0.5 (2899)	1.4 (928)	3.6 (722)	2.3 (1935)	3.7 (1587)
Aztreonam	4.2 (2488)	14.0 (1953)	11.1 (837)	2.0 (495)	7.1 (1034)	15.8 (1171)
Ampicillin Sulbactam	21.3 (4390)	22.2 (3736)	35.3 (1109)	15.9 (952)	–	15.1 (2074)
Amoxycillin/ Clavulanic acid	11.7 (1854)	16.3 (1543)	50.2 (420)	12.9 (511)	–	28.6 (754)
Carbenicillin					43.7 (2202)	
Piperacillin					17.1 (1829)	

( ) Total no. tested

third generation cephalosporins i.e cefoperazone, cefotaxime and ceftazidime, there were not much differences between them. With *E. coli* it varied from 4 to 8%; with *Klebsiella* spp it varied from 11-16% and with *Proteus* spp it varied from 3-6%. However, with *Pseudomonas aeruginosa* there was less resistance to ceftazidime (7%) followed by cefoperazone (14%) and cefotaxime (42%). Cefotaxime should therefore not be chosen in situations where the possibility of *Ps. aeruginosa* infection is high.

Gentamicin is one of the most commonly used aminoglycoside in the government hospitals. It has been recommended as empirical therapy for gram negative septicaemia. The results of this study showed that 10-88% of the gram negative bacteria isolated from blood specimens were resistant to gentamicin (Table VII-X). Therefore this recommendation should be reviewed in the light of these findings. An alternative aminoglycoside e.g amikacin may have to be used depending on the hospital's current sensitivity patterns.

Table VI
Percentage of *S. aureus* resistant to antimicrobials isolated from various specimens in six hospitals
(Aug. 91 – July 92)

Antibiotics	Blood	Urine	Pus	Sputum
Penicillin	71.9 (463)	57.3 (300)	79.9 (3582)	65.9 (91)
Methicillin	21.2 (463)	16.6 (302)	19.2 (3684)	15.2 (92)
Erythromycin	27.5 (465)	22.3 (296)	26.1 (3572)	15.42 (91)
Fusidic acid	4.6 (454)	6.1 (293)	2.8 (3458)	3.3 (91)
Cotrimoxazole	27.8 (313)	24.3 (177)	22.6 (2250)	22.7 (44)
Tetracycline	33.8 (213)	38.6 (184)	35.1 (2009)	32.8 (67)
Nitrofurantoin	–	2.3 (131)	–	–

Table VII
Percentage of *E. coli* resistant to antimicrobials isolated from various specimens in six hospitals
(Aug. 91 – July 92)

Antibiotics	Blood	Urine	Pus	Sputum
Ampicillin	52.1 (234)	46.0 (139)	58.7 (1526)	59.8 (97)
Cotrimoxazole	29.7 (239)	24.6 (134)	34.9 (1496)	28.3 (99)
Tetracycline	48.7 (117)	35.0 (100)	48.7 (879)	40.3 (67)
Cephalexin	9.7 (103)	21.4 (84)	16.6 (572)	18.3 (60)
Cefuroxime	6.3 (205)	4.3 (141)	8 (1364)	12.2 (74)
Cefoperazone	8.7 (218)	5.3 (133)	6.9 (1356)	5.9 (68)
Cefotaxime	4.9 (102)	3.7 (81)	3.9 (565)	2.6 (39)
Ceftazidime	8.9 (168)	3.1 (130)	5.4 (951)	3.2 (62)
Ceftriaxone	2.4 (41)	3.3 (30)	3.3 (210)	–
Gentamicin	10.9 (230)	11.7 (128)	10.1 (1421)	8.2 (85)
Netilmicin	9.4 (149)	6.9 (101)	8.8 (924)	3.9 (51)
Amikacin	5.8 (225)	2.9 (137)	2.2 (1271)	2.8 (71)
Norfloxacin	0.0 (15)	0.0 (14)	0.9 (228)	–
Nitrofurantoin	–	2.5 (130)	–	–
Perfloxacin	0.0 (121)	0.0 (82)	1.9 (470)	0.0 (63)
Imipenem	0.0 (130)	0.0 (86)	1.7 (527)	0.0 (51)
Aztreonam	0.0 (101)	3.4 (59)	3.7 (432)	5.0 (40)

( ) Total no. tested

Table VIII
Percentage of *Klebsiella pneumoniae* resistant to antimicrobials isolated from various specimens in six hospitals
(Aug. 91 – July 92)

Antibiotics	Blood	Urine	Pus	Sputum
Ampicillin	92.8 (125)	92.8 (641)	93.9 (652)	95.0 (581)
Cotrimoxazole	25.2 (135)	39.6 (713)	25.1 (746)	11.2 (588)
Tetracycline	22.4 (49)	37.0 (257)	24.3 (350)	12.0 (457)
Cephalexin	21.7 (46)	23.2 (250)	16.1 (254)	8.7 (311)
Cefuroxime	18.9 (122)	15.9 (327)	12.3 (677)	5.6 (483)
Cefoperazone	17.3 (150)	14.8 (623)	11.8 (671)	1.7 (524)
Cefotaxime	24.6 (69)	9.4 (181)	9.7 (196)	3.4 (233)
Ceftazidime	38.6 (88)	16.4 (286)	13.4 (268)	3.6 (33)
Ceftriaxone	26.1 (46)	17.3 (81)	11.9 (42)	2.9 (34)
Gentamicin	31.4 (140)	24.4 (664)	16.1 (665)	4.9 (576)
Netilmicin	34.3 (99)	18.4 (293)	11.1 (351)	3.4 (325)
Amikacin	12.4 (137)	4.1 (292)	4.6 (569)	1.0 (387)
Norfloxacin	0.0 (17)	1.4 (73)	0.0 (23)	0.0 (52)
Nitrofurantoin	–	10.4 (605)	–	–
Perfloxacin	2.2 (45)	0.8 (384)	1.3 (155)	0.0 (219)
Imipenem	0.0 (69)	0.2 (467)	0.5 (213)	0.4 (226)
Aztreonam	11.5 (26)	14.4 (146)	11.4 (184)	1.5 (197)

( ) Total no. tested

Table IX
Percentage of *Acinetobacter* spp resistant to antimicrobials isolated from various specimens in six hospitals
(Aug. 91 – July 92)

Antibiotics	Blood	Urine	Pus
Ampicillin	77.9 (154)	85.1 (74)	80.0 (634)
Cotrimoxazole	35.7 (154)	37.8 (74)	54.4 (641)
Tetracycline	26.4 (53)	44.6 (56)	48.4 (275)
Cephalexin	71.0 (46)	76.7 (73)	91.0 (178)
Cefuroxime	43.6 (177)	49.3 (73)	51.5 (641)
Cefoperazone	53.9 (128)	35.7 (70)	52.9 (588)
Cefotaxime	33.3 (45)	28.8 (52)	33.2 (187)
Ceftazidime	15.3 (104)	11.1 (72)	15.7 (407)
Ceftriaxone	32.1 (28)	–	23.9 (71)
Gentamicin	87.8 (155)	48.9 (47)	50.0 (602)
Netilmicin	22.4 (85)	34.8 (46)	23.3 (399)
Amikacin	22.9 (144)	8.2 (73)	21.3 (616)
Norfloxacin	33.3 (12)	–	10.9 (101)
Nitrofurantoin	–	48.5 (68)	–
Perfloxacin	5.6 (72)	9.6 (73)	5.2 (194)
Imipenem	9.2 (76)	0.0 (72)	4.1 (218)
Aztreonam	6.7 (60)	11.8 (17)	23.3 (232)

( ) Total no. tested

Cotrimoxazole is frequently used in the treatment of urinary tract infections, respiratory infections and gastrointestinal infections. *E. coli* was the commonest cause of UTI and 25% of these strains were resistant to it (Table VII). Perhaps nitrofurantoin would be a suitable alternative to be used on an empiric basis, since only 2.5% of the *E. coli* isolated from urine were resistant to it.

Erythromycin is highly active against gram positive bacteria like *S. aureus, S. pyogenes* and *S. pneumoniae.* They are often used empirically in throat and chest infections as they also have activities against mycoplasmas and chlamydia. Twenty-six per cent of the *S. aureus,* 6% of *S. pneumoniae* and 4% of *S. pyogenes* were resistant to erythromycin in this study. Therefore if erythromycin is used in penicillin allergic patients for the treatment of streptococcal infections, it must be remembered that a small proportion of this group of organisms showed *in vitro* resistance.

Tetracycline is a broad spectrum antibiotic, which is now used for a few specific infections like rickettsial, mycoplasma and chlamydial infections[8]. This is due to the high prevalence of resistant organisms in many countries. This study similarly showed the high prevalence of resistant bacteria to tetracycline. Eighteen to 60% of the gram positive and 27-50% of the gram negative bacteria were resistant to tetracycline (Tables VI and V).

Nalidixic acid was introduced into clinical use in 1964 and can be regarded as the prototype of the quinolone group of drugs[8]. Unfortunately, this drug is not available in the Ministry of Health and therefore susceptibility of bacteria to this drug was not tested although earlier surveillance by the IMR showed a low resistance rate of about 4% amongst *E. coli* strains[9]. The two fluoroquinolones tested by most of the hospital laboratories were norfloxacin and perfloxacin. These quinolones are still not widely used in this country and therefore the resistance rates are still low. With MRSA the resistance rate was about 6%. Nevertheless quinolones should not be considered first line antibiotics for MRSAs. Wide spread use of the new quinolones for the treatment of MRSA infections have led to an increase in resistance, as experienced in many areas of the United States, Canada and Japan[10,11,12]. With the *Enterobacteriaceae,* the resistance rates were from 0.7 to 1.7% (Table V). The resistance rate amongst *Pseudomonas aeruginosa* to perfloxacin was 12%. Susceptibility to ciprofloxacin was not done by most laboratories due to the non-availability of the disc.

The factors contributing to the difference in resistance rates of certain bacteria to some antimicrobial agents in the six hospitals have not been studied eg. the low resistance rate of *Enterobacteriaceae* to gentamicin in Kuala Terengganu hospital. A study should be designed to identify these factors and see how we can reduce the resistance rates of bacteria.

The emergence and increase of antimicrobial resistance in Malaysian hospitals is a constant threat and challenge to clinicians trying to control nosocomial infections. A continuous surveillance programme established in each hospital with the help of the new software programme developed in this study would alert the clinicians and therefore help in the control of such infections.

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