Annual report

Antimicrobial Resistance Surveillance Network

January 2017-December 2017

Compiled by:

Dr Kamini Walia, Ph D MPH

Maj Gen(Dr) V C Ohri, MD

Dr Harpreet Singh, PhD

Nodal centre Principal investigators	**Regional centre Principal investigators**
Typhoid: Dr Arti Kapil, AIIMS, New Delhi	Dr Camilla Rodriques. Hinduja , Mumbai
Fungal pathogens: Dr Arunaloke Chakarabarty, PGIMER, Chandigarh	Dr Chand Wattal, SGRH, New Delhi
Diarreal pathogens and GNNF: Dr V Balaji, CMC Vellore	Dr Sanjay Bhattacharya, TMC, Kolkata
Gram positive pathogens: Dr Sujatha Sistla, JIPMER, Pondicherry	Dr Sourav Sen, AFMC, Pune
Enterobacteriaceae spp: Dr Pallab Ray, PGIMER, Chandigarh	Dr Thirunarayan, Apollo Chennai
	Dr Vijayshree Deotale, MGIMS Wardha

Summary of results of ICMR surveillance data from January 2017 to December 2017

Of the total number of 45,930 isolates, 55% were from in-patients in wards, 18% were from ICUs and 27% were from outpatients. Outpatient isolates (12,336) were predominantly from pus (39%) and urine (23%), ward isolates were predominantly from pus (32%) and blood (23%) and ICU isolates were predominantly from blood (25%), pus and lower respiratory tract (16% each). Gram negatives constituted major share (74%) of the isolates overall. Gram negatives were responsible for 98% of fecal, 96% of LRT, 87% of urinary, 80% of CSF, 76% of surgical site, and 62% each of blood and pus isolates. This will have bearing in empiric choice of antibiotics. Most importantly, the fact that 76% of surgical site infections were due to gram negatives will demand revising antibiotic prophylaxis guidelines for such infections which had targeted *Staphylococci* as the predominant organism for decades. Specimen wise, predominant group of isolates included *Enterobacteriaceae* (37%) and *Staphylococci* (30%) from blood, *Enterobacteriaceae* (73%) from urine, non-fermenting gram negative bacteria(GNB) (61%) and *Enterobacteriaceae* (34%) from LRT, *Enterobacteriaceae* (38%) and *Staphylococci* (33%) from pus, non-fermenting GNB (40%) and *Enterobacteriaceae* (39%) from CSF, *Enterobacteriaceae* (46%) and non-fermenting GNB (27%) from surgical sites, and fecal pathogens (68%) from feces. The isolates from blood comprised of *Enterobacteriaceae* (37%) followed by *Staphylococci* (30%) and nonfermenting GNB (19%). Of the Enterobacteriaceae, *E. coli* was the commonest (46%) followed by *K. pneumoniae* (42%) and *Enterobacter* species (7%).

Among the typhoidal organisms, *S. typhi* is the most common etiological agent followed by *S. paratyphi* A. The ciprofloxacin susceptibility percentage was 15-18% only. Resistance in *S. paratyphi* A is higher as compared to *S. typhi*. Fluoroquinolone resistance was associated with DNA gyrase mutations. So it is no longer empirical choice. Third generation cephalosporin's are most commonly used for the treatment. But MIC_{50} and MIC_{90} showed increasing trend.

Among the diarrheal pathogens, *Aeromonas* spp is one of the most isolated species among diarrheal pathogens. *Aeromonas* spp showed moderate resistance to all tested antibiotics. Resistance to carbapenems especially imipenem, was higher compared to other classes of antibiotics. Most *Aeromonas* strains are generally susceptible to trimethoprim-sulfamethoxazole (TMP-SMX), fluoroquinolones, second and third generation cephalosporins, aminoglycosides, carbapenems, chloramphenicol, and tetracyclines. Shigella spp is the second common diarrheal pathogen and the isolates demonstrated increased resistance to nalidixic acid and trimethoprim-sulfamethoxazole (89.9%). Tetracycline still appears to be effective for *V cholerae.*

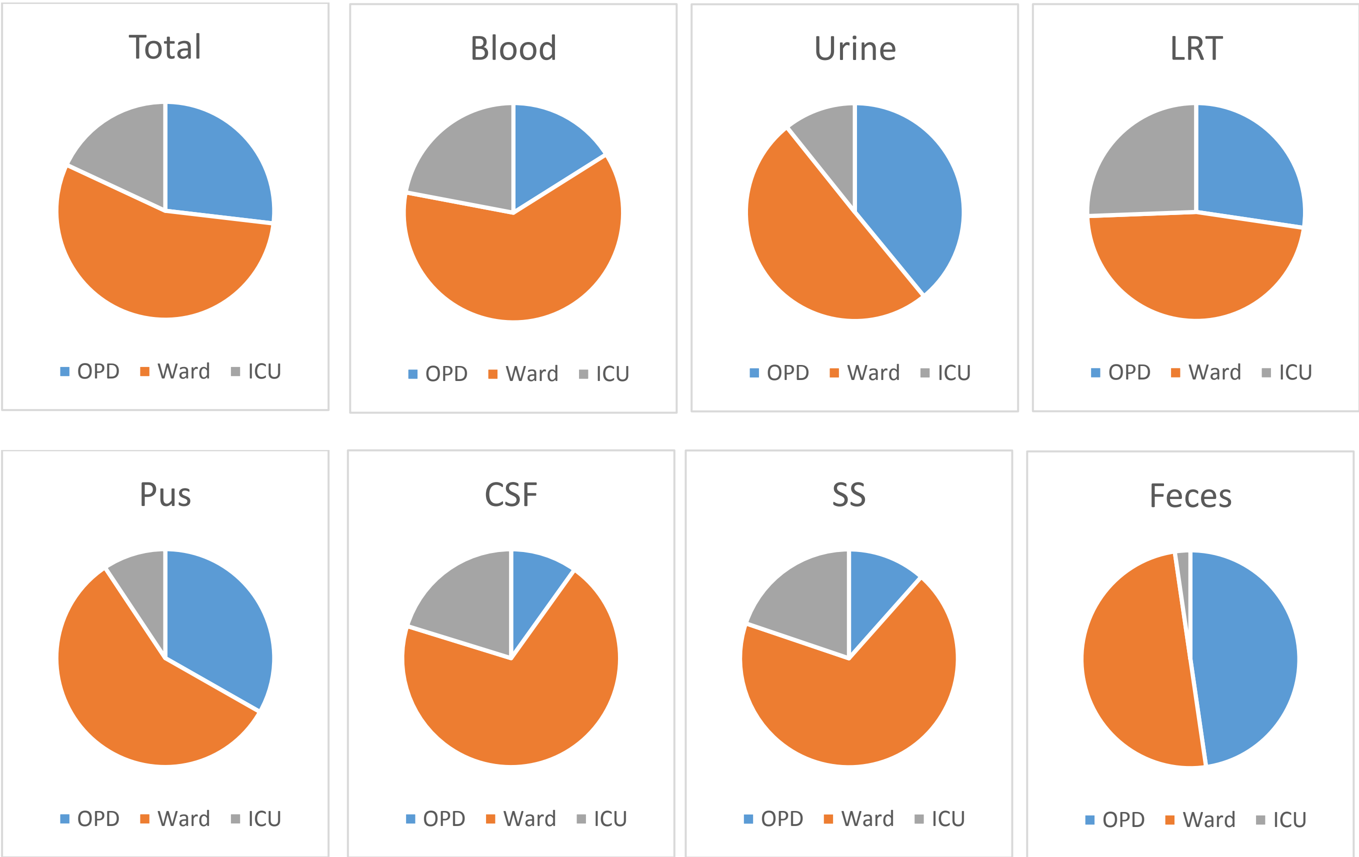


Figure i . Source of origin (OPD, ward or ICU) of isolates from various categories of specimens.

Candida tropicalis and *Aspergillus flavus* was are most commonly isolated yeast and mold respectively. *Wickerhamomyces anomalous*(13.1%) was recognized as emerging yeast in pediatric patients. Increasing resistance in *C. tropicalis* against fluconazole and caspofungin is a serious concern. Heterogeneous over expression of efflux pumps was noticed in resistant *C. tropicalis* isolates.

The overall MRSA rate for all 10 centres was slightly higher at 31.9% for the year 2017. The commonest species of CoNS are *S.haemolyticus* and *S. epidermidis* with the former demonstrating significantly higher levels of drug resistance (MRSH 86.6%, MRSE 61%). Both these species were isolated mostly from blood followed by pus. None of the centres reported VRSA or VRCoNS although VISA and VICoNS were occasionally encountered. Emergence of hVISA as revealed by the population analysis profile with highest rates seen in ICU isolates of MRSA, is a worrisome finding and is suggestive of a cumulative effect of overuse of vancomycin the hospital settings. The rates of hVISA increased with increasing level of vancomycin MICs. The other worrisome finding is the steadily increasing reports of linezolid resistance. Gram negatives constituted major share of the isolates overall. *E. coli* constituted 49% followed by *Klebsiella pneumoniae* (35%). Overall, the isolates of *Enterobacteriaceae* showed best susceptibility to colistin (94%) followed by imipenem (77%) and amikacin (75%). Moderate susceptibility was shown to meropenem (68%), ertapenem (63%), levofloxacin (60%) and piperacillin-tazobactam (52%). Poor susceptibility was found against cefotaxime (24%), ceftazidime (33%) and ciprofloxacin (35%). Against colistin maximum susceptibility was shown by E. coli (99%) followed by Enterobacter (96%), with least susceptibility by *Klebsiella pneumoniae* (87%). *Klebsiella* species were the most resistant with only colistin and imipenem showing good susceptibility and drug resistant K pneumonia infections is a major public helath concern.

Acinetobacter baumannii is resistant to all the antibiotics except to colistin. Cephalosporins like cefepime and ceftazidime shows higher resistance rates across all the specimens followed by amikacin, piperacillin-tazobactam and levofloxacin. Among carbapenems, imipenem shows increased resistance of >85% whereas meropenem shows 80%. This scenario clearly indicates that monotherapy with carbapenems are not considered to be the choice of treatment for *A. baumannii* infections. For *Pseudomonas aeruginosa*, overall, 30% resistance is seen for the anti-pseudomonal agents, with highest rates of resistance in isolates from CSF and urine.

Table i: Isolation rates of different pathogens from different specimens January 2017 to December 2017.

Isolate	Culture positive																	
	Total n=45930		Blood n=9427		Urine n=7282		LRT n=5122		Pus n=14294		CSF n=435		SS n=1177		Faeces n=478		Others n=7715	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	45930 (100)	100	9427 (100)	20.5	7282 (100)	15.9	5122 (100)	11.2	14294 (100)	31.1	435 (100)	0.9	1177 (100)	2.6	478 (100)	1	7715 (100)	16.8
OPD	12336 (26.9)	100	1515 (16.1)	12.3	2844 (39.1)	23.1	1400 (27.3)	11.3	4750 (33.2)	38.5	43 (9.9)	0.3	136 (11.6)	1.1	228 (47.7)	1.8	1420 (18.4)	11.5
Ward (non-ICU) incl HDU	25300 (55.1)	100	5836 (61.9)	23.1	3656 (50.2)	14.5	2411 (47.1)	9.5	8208 (57.4)	32.4	304 (69.9)	1.2	808 (68.6)	3.2	239 (50)	0.9	3838 (49.7)	15.2
ICU	8294 (18.1)	100	2076 (22)	25	782 (10.7)	9.4	1311 (25.6)	15.8	1336 (9.3)	16.1	88 (20.2)	1.1	233 (19.8)	2.8	11 (2.3)	0.1	2457 (31.8)	29.6
Enterobacteriaceae (except Salmonella)	19619 (42.7)	100	3528 (37.4)	18	5327 (73.2)	27.2	1740 (34)	8.9	5472 (38.3)	27.9	171 (39.3)	0.9	544 (46.2)	2.8	43 (9)	0.2	2794 (36.2)	14.2
Salmonella	491 (1.1)	100	374 (4)	76.2	2 (0)	0.4	1 (0)	0.2	10 (0.1)	2	0 (0)	0	3 (0.3)	0.6	97 (20.3)	19.8	4 (0.1)	0.8
NFGNB	12642 (27.5)	100	1792 (19)	14.2	599 (8.2)	4.7	3123 (61)	24.7	3385 (23.7)	26.8	174 (40)	1.4	322 (27.4)	2.5	5 (1)	0	3242 (42)	25.6

Staphylococci	9186 (20)	100	2828 (30)	30.8	82 (1.1)	0.9	219 (4.3)	2.4	4763 (33.3)	51.9	64 (14.7)	0.7	82 (7)	0.9	0 (0)	0	1148 (14.9)	12.5
Enterococci	2617 (5.7)	100	608 (6.4)	23.2	798 (11)	30.5	9 (0.2)	0.3	632 (4.4)	24.1	21 (4.8)	0.8	198 (16.8)	7.6	9 (1.9)	0.3	342 (4.4)	13.1
Fungi	1016 (2.2)	100	292 (3.1)	28.7	474 (6.5)	46.7	28 (0.5)	2.8	27 (0.2)	2.7	5 (1.1)	0.5	10 (0.8)	1	0 (0)	0	180 (2.3)	17.7
Faecal isolates	359 (0.8)	100	5 (0.1)	1.4	0 (0)	0	2 (0)	0.6	5 (0)	1.4	0 (0)	0	18 (1.5)	5	324 (67.8)	90.3	5 (0.1)	1.4

Table ii. Number of isolates from various specimens from patients in OPD, ward and ICU.

Culture positivity specimen wise				
	OPD	Ward	ICU	Total
Blood	1515	5836	2076	9427
Urine	2844	3656	782	7282
LRT	1400	2411	1311	5122
Pus	4750	8208	1336	14294
CSF	43	304	88	435
SS	136	808	233	1177
Feces	228	239	11	478
Others	1420	3838	2457	7715
Total	12336	25300	8294	45930

Table iii. Various organism groups distributed specimen wise. Figures in parentheses represent percentages.

Organism groups specimen wise								
	Enterobacteriaceae	**Salmonellae**	**NFGNB**	**Staphylococci**	**Enterococci**	**Fungi**	**Fecal**	**Total**
Blood	3528 (37)	374 (4)	1792 (19)	2828 (30)	608 (6)	292 (3)	5	9427
Urine	5327 (73)	2	599 (8)	82 (1)	798 (11)	474(7)	0	7282
LRT	1740 (34)	1	3123 (61)	219 (4)	9	28 (1)	2	5122
Pus	5472 (38)	10	3385 (24)	4763 (33)	632 (4)	27	5	14294
CSF	171 (39)	0	174 (40)	64 (15)	21 (5)	5 (1)	0	435
SS	544 (46)	3	322 (27)	82 (7)	198 (17)	10 (1)	18 (2)	1177
Feces	43 (9)	97 (20)	5 (1)	0	9 (2)	0	324 (68)	478
Others	2794 (36)	4	3242 (42)	1148 (15)	342 (4)	180 (2)	5	7715
Total	19619 (43)	491 (1)	12642 (28)	9186 (20)	2617 (6)	1016 (2)	359 (1)	45930

1. Tyhoidal organisms

Summary of results

The nodal coordinating center for surveillance network of antimicrobial resistance in *Salmonella enterica* serotype t*yphi* and *paratyhi A* carried out the work as per the objectives defined during 2016-2017.During this time 84 culture positive enteric fever cases were enrolled in the hospital. Of these *S. typhi* was the etiological agent in 61 followed by *S. paratyphi* A in 23.

The antibiotic used to treat the infection in pediatric patients showed that in OPD oral cefixime and ceftriaxone IV in hospitalized patients were the most common antibiotics used in our hospital. The use of fluoroquinolones is minimal and azithromycin was given mostly as an additional antibiotic in patients showing delayed response to treatment with cephalosporins. About 10% of patients needed more than one antibiotic for complete cure.

As a nodal center we received a total of 266 strains (*S. typhi*-166, *S. paratyphi* A 74 and salmonella spp-26) from various regional centers. The cumulative antibiogram showed that 5% strains were MDR while susceptibility to ciprofloxacin varies from 15-18% in different centers. All the strains were susceptible to ceftriaxone but MIC_{50} and MIC_{90} showed an increasing trend.

Mechanism of fluoroquinolones resistance at molecular level was studied in 100 Typhoidal isolates. The Mutations in DNA gyrase was the most common cause with mutations at S83 to F/Y followed by D87 to N/G/Y. *Par*C mutation was detected in three isolates only. No mutation was detected in *gyr*B and *par* genes. Strains with more than one mutation in gyrase A gene had higher MICs. Efflux pump was not responsible for resistance. *Qnr* B was found in two *Salmonella typhimurium* isolates from Vellore but not in typhoidal Salmonella. None of the isolate was positive for ESBL genes.

Molecular typing was done by MLST (multiple locus sequence typing) and PFGE (Pulse field gel electrophoresis).By MLST, *Salmonella typhi* was grouped in ST1 and ST2 sequence types and *Salmonella paratyphi A* was grouped in ST85 and ST129.PFGE was done in representative typhoidal *Salmonellae* from all the centers. Similarity coefficient was calculated and two type of PFP (Pulsed Field Profile) were observed in the studied isolates.

To summarize *S. typhi* is the most common etiological agent followed by *S. paratyphi A*. The ciprofloxacin susceptibility percentage was 40-50% only. Resistance in *S. paratyphi* A is higher as compared to *S. typhi*. Fluoroquinolone resistance was associated with DNA gyrase mutations. So it is no longer empirical choice. Third generation cephalosporin’s are most commonly used for the treatment. But MIC_{50} and MIC_{90} showed increasing trend.

Table 1.1: Isolation rates of *Salmonellae* from different sample types

Isolate	Blood n=9427		Faeces n=478	
	n	%	n	%
Salmonella paratyphi A	39	0.4	2	0.4
Salmonella typhi	308	3.3	64	13.4
Salmonella spp.	27	0.3	31	6.5
Total Salmonella	374	4	381	79.7

Table 1.2: Resistance pattern of *Salmonella* isolates. (If number of isolates of particular species ≥ 20).

AMA	Blood		
	***Salmonella paratyphi A* n=34**	***Salmonella typhi* n=234**	***Salmonella spp.* n=25**
Ampicillin	1/33 (3)	17/224 (7.6)	1/24 (4.2)
Azithromycin	*0/0 (-)	6/163 (3.7)	*0/0 (-)
Cefixime	1/22 (4.5)	2/162 (1.2)	*0/7 (-)
Ceftriaxone	0/34 (0)	1/233 (0.4)	1/25 (4)
Chloramphenicol	0/31 (0)	8/198 (4)	0/20 (0)
Ciprofloxacin	18/34 (52.9)	74/200 (37)	*4/19 (-)
Levofloxacin	*1/1 (-)	*2/2 (-)	*0/0 (-)
Ofloxacin	*0/0 (-)	*0/0 (-)	*0/0 (-)
Pefloxacin	*2/6 (-)	85/116 (73.3)	*0/0 (-)
Trimethoprim-sulfamethoxazole	12/34 (35.3)	52/231 (22.5)	7/25 (28)

2. Diarrheal pathogens

Aeromonas spp

Aeromonas spp is one of the most isolated species among diarrheal pathogens (~51%). *Aeromonas* spp showed moderate resistance to all tested antibiotics. Resistance to carbapenems especially imipenem, appears to be higher (31%) compared to other classes of antibiotics. Most *Aeromonas* strains exhibits lower resistance to fluoroquinolones (~15%), third generation cephalosporins (3/8), carbapenems (~30%) and tetracyclines (16%). Hence empiric therapy with quinolones and third generation cephalosporin for suspected *Aeromonas* infections is recommended. In addition, as per CLSI, usage of certain agents like ampicillin should be avoided, as all species of clinical aeromonads are resistant to ampicillin.

Shigella spp

Shigella spp is the second common diarrheal pathogen (44%). *S. flexneri* was the predominant serotype isolated followed by *S. sonnei*. Increased resistance was observed for first line antibiotic ampicillin (53.3%). High level resistance was observed to nalidixic acid (96.4%) and trimethoprim-sulfamethoxazole (89.9%). Ampicillin resistance was higher in *S. flexneri* when compared to *S. sonnei*. These drugs suggestively are not to be recommended unless susceptibility is known or expected based on local surveillance. Notably, resistant to third generation cephalosporin (cefixime) seems to be higher in *S. flexneri* (19.1%) compared to S. sonnei (6.4%). This may be due to the fact that *S. flexneri* serotype is more commonly isolated and increasing usage of cefixime as an oral antibiotic. Quinolones such as norfloxacin and third generation cephalosporin such as ceftriaxone/cefixime are considered to be effective in the management of *Shigella* infection. Azithromycin can also be considered as a secondary choice for therapy. However emerging resistance is observed to these newer drugs. Hence continuous surveillance on changing trend of antimicrobial susceptibility of this pathogen is essential particularly in *Shigella* endemic region like India.

Vibrio cholerae

Tetracycline/ doxycycline is the usual choice of antibiotic. Tetracycline susceptibility was found higher (2/17). Whereas, trimethoprim-sulfamethoxazole susceptibility was lesser (11/19) followed by ampicillin (7/20) and quinolone such as nalidixic acid (6/8) and norfloxacin (5/14). This suggest that this organism begun to develop resistance against ampicillin, trimethoprim-sulfamethoxazole and nalidixic acid, therefore these drugs could be avoided for use as first line therapy. However, tetracycline still appears to be effective, but the choice of which will depend on local drug susceptibility data. Continuous surveillance of drug resistant strains is very important to know the changing antibiotic susceptibility pattern, along with the changing serogroups from time to time as the resistance pattern also changes with the change in the serogroups.

Table 2.1: Isolation rates of bacterial pathogens from faeces.

Isolate	Total positive cultures 'n' = 45340	
	n	%
Salmonella	21	0
Salmonella typhimurium faecal	3	0
Salmonella spp. faecal	18	0
Shigella	144	0.3
Shigella flexneri	94	0.2
Shigella sonnei	49	0.1
Shigella spp.	1	0
Vibrio	26	0.1
Vibrio cholerae	25	0.1
Vibrio spp.	1	0
Aeromonas spp.	167	0.4

Aeromonas

Table 2.2: Resistance percentages of *Aeromonas* isolates. (If isolates ≥20)

AMA	All Specimens
	***Aeromonas* spp. n=167**
Cefixime	*3/8 (-)
Ciprofloxacin	14/80 (17.5)
Imipenem	13/42 (31)
Meropenem	8/43 (18.6)
Norfloxacin	8/61 (13.1)
Tetracycline	26/160 (16.3)

Shigella

Table 2.3 : Resistance pattern of *Shigella* isolates. (If number of isolates of particular species ≥ 20).

AMA	Faeces	
	Shigella flexneri **n=92**	***Shigella sonnei*** **n=49**
Ampicillin	49/92 (53.3)	14/49 (28.6)
Cefixime	13/68 (19.1)	3/47 (6.4)
Nalidixic acid	27/28 (96.4)	*8/8 (-)
Norfloxacin	7/28 (25)	*0/8 (-)
Trimethoprim-sulfamethoxazole	62/69 (89.9)	44/49 (89.8)
Azithromycin	8/43 (18.6)	15/44 (34)

Vibrio

Table 2.4: Resistance pattern of *Vibrio* isolates. (If number of isolates of particular species ≥ 20).

AMA	**Faeces**
	Vibrio cholerae **n=20**
Ampicillin	7/20 (35)
Nalidixic acid	*6/8 (-)
Norfloxacin	*5/14 (-)
Tetracycline	*2/17 (-)
Trimethoprim-sulfamethoxazole	*11/19 (-)

3. *Gram positive cocci*

Summary of results

Details of 45930 bacterial isolates were uploaded to ICMR online portal from ten centres across India for the year 2017. Of these, 9186 were staphylococci (6297 *S.aureus* and 2889 CoNS) and 2617 were enterococci (1157 *E.faecalis*, 1034 *E.faecium* and 426 *Enterococcus* spp).

The proportion of MRSA has steadily decreased over the last 4 years from 37% in 2014 to 34% in 2015 and 28% in 2016 to 23.5% in 2017 possibly reflecting improved infection control measures. These figures are from nodal center (JIPMER).However the overall MRSA rate for all 10 centres was slightly higher at 31.9% for the year 2017.

Most laboratories in the country depend on cefoxitin disc diffusion to identify MRSA. It has been observed that this test tends to misidentify a significant number of isolates regardless of the source of the discs. As a nodal centre we are confirming the disc diffusion test with mecA PCR and LAT for PBP2a and a lot of discrepancies have been noticed from all centres on the isolates sent for quality control. Overall, mecA gene PCR was positive in most isolates of MRSA with a very few exceptions. These false negative results could indicate mutation in the primer binding region.

The commonest species of CoNS are *S.haemolyticus* and *S. epidermidis* with the former demonstrating significantly higher levels of drug resistance (MRSH 86.6%, MRSE 61%). Both these species were isolated mostly from blood followed by pus. The other species of CoNS identified in much smaller numbers included S.hominis, S.lugdunensis and *S.saprophyticus*.

None of the centres reported VRSA or VRCoNS although VISA and VICoNS were occasionally encountered. More worrying is the emergence of hVISA as revealed by the population analysis profile, highest rates seen in ICU isolates of MRSA, suggesting a cumulative effect of overuse of vancomycin the hospital setting. This study was performed only on MRSA isolates from the nodal center (JIPMER). The rates of hVISA increased with increasing level of vancomycin MICs. The treatment response and outcome in patients from whom hVISA has been isolated needs to be monitored.

The other worrisome finding is the steadily increasing reports of linezolid resistance. 0.3% of *S.aureus*, 1.3% of CoNS and 2.5% of Enterococcus isolates exhibited this phenotype. This may reflect the increased usage of linezolid in hospitals because of the availability of oral formulations. Cfrgene was performed to monitor linezolid resistance from CoNS and *Enterococcus* isolates at the nodal centre (JIPMER). 10/12 isolates of CoNS demonstrated the presence of Cfr gene. However none of the enterococci were positive for this gene.

Overall teicoplanin resistance was observed in 6 (0.15%) isolates of methicillin sensitive *Staphylococus aureus* and 0.5(10%) in MRSA. In CoNS,teicoplanin resistance was found 0.6% of *S.hemolyticus* and in0.7% *of S.hominis*.Teicoplanin resistance was confirmed by MIC determination using E test. All these isolates were vancomycin sensitive

Overall Mupirocin resistance (2 %) among MRSA and 1.3 % in MSSA ,has remained relatively constant over the past 4 years possibly suggesting that mupirocin resistance genes exert a large fitness cost on MRSA.

VRE rates have also shown a declining trend from around 7% in 2015 to about 4% in 2016 and 2017(JIPMER data). Overall vancomycin resistance as expected was three times higher in *E.faecium*(21.5%) as compared to *E.faecalis* (3.9%). All the tested VRE isolates were positive only for van A gene.

Table 3.1: Isolation rates of different *Staphylococci* from different specimens

Isolate	Culture positive																	
	Total n=45930		Blood n=9427		Urine n=7282		LRT n=5122		Pus n=14294		CSF n=435		SS n=1177		Faeces n=478		Others n=7715	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	45930 (100)	100	9427 (100)	20.5	7282 (100)	15.9	5122 (100)	11.2	14294 (100)	31.1	435 (100)	0.9	1177 (100)	2.6	478 (100)	1	7715 (100)	16.8
Staphylococci	9186 (20)	100	2828 (30)	30.8	82 (1.1)	0.9	219 (4.3)	2.4	4763 (33.3)	51.9	64 (14.7)	0.7	82 (7)	0.9	0 (0)	0	1148 (14.9)	12.5
Staphylococcus aureus	6297 (13.7)	100	899 (9.5)	14.3	69 (0.9)	1.1	202 (3.9)	3.2	4124 (28.9)	65.5	33 (7.6)	0.5	47 (4)	0.7	0 (0)	0	923 (12)	14.7
MSSA	4238 (9.2)	100	552 (5.9)	13	42 (0.6)	1	123 (2.4)	2.9	2818 (19.7)	66.5	21 (4.8)	0.5	36 (3.1)	0.8	0 (0)	0	646 (8.4)	15.2
MRSA	2015 (4.4)	100	330 (3.5)	16.4	27 (0.4)	1.3	76 (1.5)	3.8	1283 (9)	63.7	12 (2.8)	0.6	11 (0.9)	0.5	0 (0)	0	276 (3.6)	13.7
CoNS	2889 (6.3)	100	1929 (20.5)	66.8	13 (0.2)	0.4	17 (0.3)	0.6	639 (4.5)	22.1	31 (7.1)	1.1	35 (3)	1.2	0 (0)	0	225 (2.9)	7.8

Staphylococcus haemolyticus	**657 (1.4)**	**100**	**360 (3.8)**	**54.8**	**2 (0)**	**0.3**	**2 (0)**	**0.3**	**190 (1.3)**	**28.9**	**1 (0.2)**	**0.2**	**11 (0.9)**	**1.7**	**0 (0)**	**0**	**91 (1.2)**	**13.9**
Staphylococcus epidermidis	**622 (1.4)**	**100**	**393 (4.2)**	**63.2**	**2 (0)**	**0.3**	**4 (0.1)**	**0.6**	**160 (1.1)**	**25.7**	**11 (2.5)**	**1.8**	**7 (0.6)**	**1.1**	**0 (0)**	**0**	**45 (0.6)**	**7.2**
Staphylococcus hominis	**394 (0.9)**	**100**	**341 (3.6)**	**86.5**	**0 (0)**	**0**	**0 (0)**	**0**	**32 (0.2)**	**8.1**	**2 (0.5)**	**0.5**	**4 (0.3)**	**1**	**0 (0)**	**0**	**15 (0.2)**	**3.8**
Staphylococcus spp.	**1185 (2.6)**	**100**	**824 (8.7)**	**69.5**	**5 (0.1)**	**0.4**	**11 (0.2)**	**0.9**	**246 (1.7)**	**20.8**	**17 (3.9)**	**1.4**	**11 (0.9)**	**0.9**	**0 (0)**	**0**	**71 (0.9)**	**6**

Table 3.2: Isolation rates of different *Enterococci* from different specimens

Isolate	Culture positive																	
	Total n=45930		Blood n=9427		Urine n=7282		LRT n=5122		Pus n=14294		CSF n=435		SS n=1177		Faeces n=478		Others n=7715	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	45930 (100)	100	9427 (100)	20.5	7282 (100)	15.9	5122 (100)	11.2	14294 (100)	31.1	435 (100)	0.9	1177 (100)	2.6	478 (100)	1	7715 (100)	16.8
Enterococci	2617 (5.7)	100	608 (6.4)	23.2	798 (11)	30.5	9 (0.2)	0.3	632 (4.4)	24.1	21 (4.8)	0.8	198 (16.8)	7.6	9 (1.9)	0.3	342 (4.4)	13.1
Enterococcus faecalis	1157 (2.5)	100	142 (1.5)	12.3	415 (5.7)	35.9	4 (0.1)	0.3	329 (2.3)	28.4	9 (2.1)	0.8	49 (4.2)	4.2	0 (0)	0	209 (2.7)	18.1
Enterococcus faecium	1034 (2.3)	100	336 (3.6)	32.5	267 (3.7)	25.8	4 (0.1)	0.4	224 (1.6)	21.7	10 (2.3)	1	78 (6.6)	7.5	9 (1.9)	0.9	106 (1.4)	10.3
Enterococcus spp.	426 (0.9)	100	130 (1.4)	30.5	116 (1.6)	27.2	1 (0)	0.2	79 (0.6)	18.5	2 (0.5)	0.5	71 (6)	16.7	0 (0)	0	27 (0.3)	6.3

Table3.3 : Resistance percentages of *Staphylococci* isolated from all specimen

AMA	All Specimens			
	Sau n=6049	MSSA n=4098	MRSA n=1907	CoNS n=2551
Cefoxitin	1917/6008 (31.9)	0/4081 (0)	1901/1904 (99.8)	1682/2538 (66.3)
Ciprofloxacin	3305/5737 (57.6)	2063/3886 (53.1)	1220/1809 (67.4)	1048/2270 (46.2)
Clindamycin	1214/5899 (20.6)	503/4005 (12.6)	705/1863 (37.8)	1018/2521 (40.4)
Erythromycin	1998/5917 (33.8)	954/4021 (23.7)	1031/1854 (55.6)	1383/2400 (57.6)
Linezolid	17/5716 (0.3)	4/3877 (0.1)	13/1800 (0.7)	34/2296 (1.5)
Mupirocin High Level	52/3511 (1.5)	26/2517 (1)	26/974 (2.7)	*0/0 (-)
Oritavancin	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)
Oxacillin	84/316 (26.6)	0/225 (0)	84/91 (92.3)	*0/3 (-)
Penicillin	3696/3991 (92.6)	2489/2766 (90)	1179/1189 (99.2)	971/1189 (81.7)
Teicoplanin	17/5730 (0.3)	6/3885 (0.2)	10/1815 (0.6)	12/2272 (0.5)

Tetracycline	312/4344 (7.2)	125/3041 (4.1)	186/1280 (14.5)	153/1320 (11.6)
Tigecycline	2/316 (0.6)	2/224 (0.9)	0/92 (0)	3/143 (2.1)
Trimethoprim-sulfamethoxazole	1281/4649 (27.6)	794/3253 (24.4)	481/1360 (35.4)	833/1587 (52.5)
Vancomycin	0/3044 (0)	0/2284 (0)	0/759 (0)	0/777 (0)

Note: Sau: *Staphylococcus aureus*, MSSA: Methicillin susceptible *S. aureus*, MRSA: Methicillin resistant *S. aureus*,CoNS: Coagulase negative staphylococci.

Table 3.4: Resistance percentages of *Staphylococci* isolated from different health care area from all specimen (except urine and faeces)

AMA	*Staphylococcus aureus* Total n=2007 (R%)	*Staphylococcus aureus* OPD n=893 (R%)	*Staphylococcus aureus* Ward n=937 (R%)	*Staphylococcus aureus* ICU n=177 (R%)	MSSA Total n=1457 (R%)	MSSA OPD n=686 (R%)	MSSA Ward n=660 (R%)	MSSA ICU n=111 (R%)	MRSA Total n=547 (R%)	MRSA OPD n=206 (R%)	MRSA Ward n=276 (R%)	MRSA ICU n=65 (R%)	CoNS Total n=889 (R%)	CoNS OPD n=139 (R%)	CoNS Ward n=594 (R%)	CoNS ICU n=156 (R%)
Cefoxitin	547/ 2004 (27.3)	206/ 892 (23.1)	276 /936 (29.5)	65/ 176 (36.9)	0/1457 (0)	0/686 (0)	0/660 (0)	0/111 (0)	547/ 547 (100)	206 /206 (100)	276/ 276 (100)	65/65 (100)	550/ 889 (61.9)	67/ 139 (48.2)	361 /594 (60.8)	122 /156 (78.2)
Ciprofloxacin	1086/ 1975 (55)	466/ 889 (52.4)	522/ 913 (57.2)	98/ 173 (56.6)	720/ 1437 (50.1)	334/ 683 (48.9)	333/ 645 (51.6)	53/ 109 (48.6)	365/ 536 (68.1)	131/ 205 (63.9)	189/ 267 (70.8)	45/ 64 (70.3)	394/ 878 (44.9)	54/13 6 (39.7)	268/5 87 (45.7)	72/15 5 (46.5)
Clindamycin	432/ 1993 (21.7)	167/ 891 (18.7)	218/ 927 (23.5)	47/ 175 (26.9)	228/ 1450 (15.7)	103/ 685 (15)	107/ 654 (16.4)	18/ 111 (16.2)	204/ 541 (37.7)	64/205 (31.2)	111/ 272 (40.8)	29/64 (45.3)	380/ 878 (43.3)	39/13 6 (28.7)	245/5 87 (41.7)	96/15 5 (61.9)
Erythromycin	611/ 2000 (30.6)	237/ 890 (26.6)	318/ 934 (34)	56/ 176 (31.8)	340/ 1454 (23.4)	148/ 683 (21.7)	168/ 660 (25.5)	24/ 111 (21.6)	271/ 544 (49.8)	89/206 (43.2)	150/ 273 (54.9)	32/65 (49.2)	473/8 88 (53.3)	63/13 9 (45.3)	306/5 93 (51.6)	104/1 56 (66.7)
Linezolid	5/1721 (0.3)	3/771 (0.4)	1/817 (0.1)	1/133 (0.8)	2/1269 (0.2)	2/603 (0.3)	0/578 (0)	0/88 (0)	3/450 (0.7)	1/167 (0.6)	1/238 (0.4)	1/45 (2.2)	9/658 (1.4)	1/125 (0.8)	6/432 (1.4)	2/101 (2)
Mupirocin High Level	23/1178 (2)	6/526 (1.1)	15/558 (2.7)	2/94 (2.1)	12/875 (1.4)	4/409 (1)	7/397 (1.8)	1/69 (1.4)	11/30 3 (3.6)	2/117 (1.7)	8/161 (5)	1/25 (4)	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)

Penicillin	1288/1394 (92.4)	597/641 (93.1)	604/653 (92.5)	87/100 (87)	923/1026 (90)	454/497 (91.3)	410/458 (89.5)	59/71 (83.1)	365/368 (99.2)	143/144 (99.3)	194/195 (99.5)	28/29 (96.6)	330/430 (76.7)	73/101 (72.3)	208/270 (77)	49/59 (83.1)
Teicoplanin	8/1973 (0.4)	4/887 (0.5)	3/912 (0.3)	1/174 (0.6)	4/1435 (0.3)	3/682 (0.4)	1/643 (0.2)	0/110 (0)	3/535 (0.6)	1/204 (0.5)	1/268 (0.4)	1/63 (1.6)	4/878 (0.5)	0/138 (0)	3/587 (0.5)	1/153 (0.7)
Tetracycline	87/1398 (6.2)	36/643 (5.6)	45/655 (6.9)	6/100 (6)	38/1028 (3.7)	17/498 (3.4)	18/459 (3.9)	3/71 (4.2)	49/370 (13.2)	19/145 (13.1)	27/196 (13.8)	3/29 (10.3)	56/432 (13)	10/101 (9.9)	40/272 (14.7)	6/59 (10.2)
Trimethoprim-sulfamethoxazole	424/1421 (29.8)	194/646 (30)	201/673 (29.9)	29/102 (28.4)	269/1045 (25.7)	131/502 (26.1)	120/471 (25.5)	18/72 (25)	155/376 (41.2)	63/144 (43.8)	81/202 (40.1)	11/30 (36.7)	196/441 (44.4)	39/104 (37.5)	127/277 (45.8)	30/60 (50)
Vancomycin	0/1031 (0)	0/468 (0)	0/477 (0)	0/86 (0)	0/781 (0)	0/373 (0)	0/342 (0)	0/66 (0)	0/250 (0)	0/95 (0)	0/135 (0)	0/20 (0)	0/179 (0)	0/45 (0)	0/111 (0)	0/23 (0)

Coagulase negative Staphylocicci

Table 3.5: Resistance percentages of CoNS isolated from all specimen

AMA	All Specimens					
	***Staphylococcus epidermidis* n=608**	***Staphylococcus haemolyticus* n=641**	***Staphylococcus hominis* n=390**	***Staphylococcus lugdunensis* n=*14**	***Staphylococcus saprophyticus* n=*12**	***Staphylococcus* spp. n=886**
Cefoxitin	366/600 (61)	555/641 (86.6)	253/389 (65)	*4/13 (-)	*4/12 (-)	500/883 (56.6)
Ciprofloxacin	156/604 (25.8)	452/641 (70.5)	170/390 (43.6)	*3/14 (-)	*3/12 (-)	264/609 (43.3)
Clindamycin	245/605 (40.5)	353/640 (55.2)	126/390 (32.3)	*2/13 (-)	*3/12 (-)	289/861 (33.6)
Erythromycin	356/606 (58.7)	418/639 (65.4)	235/389 (60.4)	*3/14 (-)	*3/12 (-)	368/740 (49.7)
Linezolid	5/504 (1)	16/559 (2.9)	3/338 (0.9)	*0/14 (-)	*0/11 (-)	10/870 (1.1)
Penicillin	177/229 (77.3)	292/319 (91.5)	70/84 (83.3)	*8/10 (-)	*3/5 (-)	421/542 (77.7)
Teicoplanin	2/606 (0.3)	4/637 (0.6)	3/384 (0.8)	*0/14 (-)	*0/12 (-)	3/619 (0.5)
Tetracycline	25/269 (9.3)	37/368 (10.1)	14/100 (14)	*1/14 (-)	*1/7 (-)	75/562 (13.3)
Tigecycline	1/60	1/22	0/25	*0/0	*0/2	1/34

	(1.7)	(4.5)	(0)	(-)	(-)	(2.9)
Trimethoprim-sulfamethoxazole	144/269 (53.5)	223/365 (61.1)	52/97 (53.6)	*8/14 (-)	*2/8 (-)	404/834 (48.4)
Vancomycin	0/145 (0)	0/232 (0)	0/75 (0)	*0/9 (-)	*0/5 (-)	0/311 (0)

Enterococci

Table 3.6: Resistance percentages of *Enterococci* isolated from different specimen (except urine)

AMA	All Specimens (except urine)		Blood		LRT		Pus		CSF	SS	
	Enterococcus faecalis n=716	Enterococcus faecium n=742	Enterococcus faecalis n=135	Enterococcus faecium n=323	Enterococcus faecalis n=*13	Enterococcus faecium n=*16	Enterococcus faecalis n=323	Enterococcus faecium n=215	Enterococcus faecium n=*10	Enterococcus faecalis n=49	Enterococcus faecium n=78
Ampicillin	255/684 (37.3)	509/682 (74.6)	48/118 (40.7)	206/289 (71.3)	*5/12 (-)	*13/15 (-)	116/317 (36.6)	163/202 (80.7)	*10/10 (-)	20/48 (41.7)	50/77 (64.9)
Gentamicin HL	290/677 (42.8)	431/592 (72.8)	66/110 (60)	175/222 (78.8)	*6/13 (-)	*10/14 (-)	125/322 (38.8)	149/213 (70)	*9/10 (-)	21/41 (51.2)	20/35 (57.1)
Linezolid	6/706 (0.8)	31/724 (4.3)	2/132 (1.5)	19/315 (6)	*0/13 (-)	*1/15 (-)	0/323 (0)	5/215 (2.3)	*1/9 (-)	2/49 (4.1)	3/75 (4)
Teicoplanin	26/713 (3.6)	117/735 (15.9)	7/135 (5.2)	67/319 (21)	*1/13 (-)	*1/16 (-)	10/322 (3.1)	30/213 (14.1)	*1/10 (-)	3/49 (6.1)	10/78 (12.8)
Vancomycin	28/701 (4)	155/720 (21.5)	8/123 (6.5)	84/304 (27.6)	*1/13 (-)	*1/16 (-)	11/322 (3.4)	44/212 (20.8)	*2/10 (-)	3/48 (6.3)	10/78 (12.8)

Table 3.7: Resistance percentages of Enterococci isolated from different health care areas from all specimen (except faeces). (If isolates number ≥20)

AMA	*Enterococcus faecalis*				*Enterococcus faecium*			
	Total n=326	OPD n=71	Ward n=201	ICU n=54	Total n=435	OPD n=55	Ward n=283	ICU n=97
	(R%)	(R%)	(R%)	(R%)	(R%)	(R%)	(R%)	(R%)
Ampicillin	96/322 (29.8)	10/71 (14.1)	57/197 (28.9)	29/54 (53.7)	326/422 (77.3)	37/53 (69.8)	206/276 (74.6)	83/93 (89.2)
Ciprofloxacin	96/120 (80)	25/38 (65.8)	59/69 (85.5)	*12/13 -	100/104 (96.2)	*11/13 -	60/62 (96.8)	29/29 (100)
Gentamicin HL	125/314 (39.8)	14/69 (20.3)	86/193 (44.6)	25/52 (48.1)	250/355 (70.4)	32/44 (72.7)	160/223 (71.7)	58/88 (65.9)
Linezolid	4/325 (1.2)	0/71 (0)	4/201 (2)	0/53 (0)	11/428 (2.6)	1/54 (1.9)	9/279 (3.2)	1/95 (1.1)
Nitrofurantoin	9/120 (7.5)	0/38 (0)	6/69 (8.7)	*3/13 -	38/102 (37.3)	*3/13 -	22/60 (36.7)	13/29 (44.8)
Teicoplanin	9/324 (2.8)	2/70 (2.9)	5/201 (2.5)	2/53 (3.8)	53/431 (12.3)	7/54 (13)	30/281 (10.7)	16/96 (16.7)
Vancomycin	10/324 (3.1)	2/71 (2.8)	5/199 (2.5)	3/54 (5.6)	74/431 (17.2)	10/54 (18.5)	41/281 (14.6)	23/96 (24)

4. Fungal isolates

Summary of results

From the four participating centers a total of 1249 fungi (967 yeasts and 282 mold) isolated from invasive infections were studied. *Candida tropicalis*(34.6%) and *Aspergillus flavus* was major yeast and mold respectively. *Wickerhamomyces anomalous*(13.1%) was recognized as emerging yeast inpediatric patients. Increasing resistance in *C. tropicalis* against fluconazole (5%), and caspofungin(5.7%) is a major concern. Heterogeneous over expression of efflux pumps was noticed in resistant *C. tropicalis* isolates. Fluconazole resistance with *C. albicans*(7%) is similar to earlier rate observed, but increasing trends of resistance to voriconazole(4.9%) and caspofungin(4.4%) have been noted. Among other non-Candida yeasts, no resistance against evaluated antifungal agents was noted.Among molds, we determined high posaconazole and itraconazole MIC's to *Rhizopus arrhizus* in all the isolates tested and high amphotericin MIC's to *A. flavus*. Significant increase in the expression of CDR1 gene was noted with azole resistant *A. flavus* isolates. A multidrug resistant yeast, *C. auris* was isolated from two centers. *C. auris* surveillance conducted in ICUs of our center revealed the persistence of this yeast in the hospital environment and as a colonizer in the patients after admission to hospital. None of the patients carried this agent at the time of admission. Intervention in the form of chlorhexidine body wash and proper use of disinfectants helped in containing *C. auris* outbreak in our hospital. Therapeutic drug monitoring of voriconazole and itraconazole carried out in this study helped the clinicians to optimise antifungal therapy.

Table 4.1: Isolation rates of different fungi from different specimens

Isolate	Total n=45340		Blood n=2935		Urine n=2212		LRT n=1854		Pus n=5631		Genital n=98		Others n=31808	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	45340 (100)	100	2935 (100)	6.5	2212 (100)	4.9	1854 (100)	4.1	5631 (100)	12.4	98 (100)	0.2	31808 (100)	70.2
Fungal isolates	1016 (2.2)	100	104 (3.5)	10.2	242 (10.9)	23.8	2 (0.1)	0.2	4 (0.1)	0.4	79 (80.6)	7.8	575 (1.8)	56.6
Yeasts	998 (2.2)	100	104 (3.5)	10.4	242 (10.9)	24.2	2 (0.1)	0.2	4 (0.1)	0.4	79 (80.6)	7.9	557 (1.8)	55.8
-Candida	998 (2.2)	100	104 (3.5)	10.4	242 (10.9)	24.2	2 (0.1)	0.2	4 (0.1)	0.4	79 (80.6)	7.9	557 (1.8)	55.8
Candida krusei	24 (0.1)	100	7 (0.2)	29.2	1 (0)	4.2	0 (0)	0	0 (0)	0	3 (3.1)	12.5	13 (0)	54.2
Candida albicans	359 (0.8)	100	26 (0.9)	7.2	81 (3.7)	22.6	1 (0.1)	0.3	2 (0)	0.6	49 (50)	13.6	198 (0.6)	55.2
Candida guilliermondii	3 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	3 (0)	-
Candida glabrata	101 (0.2)	100	10 (0.3)	9.9	15 (0.7)	14.9	0 (0)	0	0 (0)	0	21 (21.4)	20.8	54 (0.2)	53.5
Candida	56	100	13	23.2	7	12.5	1	1.8	0	0	0	0	34	60.7

parapsilosis	(0.1)		(0.4)		(0.3)		(0.1)		(0)		(0)		(0.1)	
Candida tropicalis	455 (1)	100	48 (1.6)	10.5	138 (6.2)	30.3	0 (0)	0	2 (0)	0.4	6 (6.1)	1.3	255 (0.8)	56
Moulds	18 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	18 (0.1)	-
+Aspergillus	18 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	18 (0.1)	-

1. *Percentages are out of paricular specimen (column).*
2. *Percentages in rows below Culture positive are out of Culture positive in respective columns.*
3. *LRT (Lower Respiratory Tract) includes sputum, BAL and others.*
4. *Pus includes pus swabs and aspirates.*
5. *SS: Sterile sites.*

Table 4.2: Resistance percentages of Candida spp. isolated from all specimen.

AMA	All Specimens				
	Candida albicans n=359	**Candida glabrata n=101**	**Candida krusei n=24**	**Candida parapsilosis n=56**	**Candida tropicalis n=455**
Anidulafungin	0/114 (0)	*1/19 (-)	*0/16 (-)	0/35 (0)	0/150 (0)
Caspofungin	2/118 (1.7)	*0/18 (-)	*2/16 (-)	0/35 (0)	0/151 (0)
Fluconazole	2/357 (0.6)	0/101 (0)	*3/13 (-)	2/56 (3.6)	6/453 (1.3)
Micafungin	0/118 (0)	*0/9 (-)	*0/15 (-)	0/35 (0)	0/151 (0)
Voriconazole	2/352 (0.6)	1/56 (1.8)	0/24 (0)	0/52 (0)	4/451 (0.9)

Table 4.3: Resistance percentages of Aspergillus spp. isolated from all specimen. (If isolates ≥20)

AMA	All Specimens
	Aspergillus flavus **n=*14**
Amphotericin B	*6/14 (-)
Caspofungin	*0/14 (-)
Itraconazole	*0/14 (-)
Posaconazole	*0/14 (-)
Voriconazole	*0/14 (-)

Note: Afa: *A. flavus,* Afum: *A. fumigates,* Anid: *A. nidulans,* Anig: *A. niger,* Ater: *A. terreus,* Aver: *A. versicolor*

5. Non-Fermenting Gram-negative bacteria(NFGNB)

Summary of results

Pseudomonas aeruginosa

Pseudomonas aeruginosa is the most common pathogen isolated from LRT (33.2%), followed by Pus (14.2%), Skin and soft tissue infections (12.6%), Urine (6.2%) and Blood (5.9%). Overall, 30% resistance is seen for the anti-pseudomonal agents, with highest rates of resistance in isolates from CSF and Urine. Worryingly, colistin resistance is seen in about 4% of isolates causing blood stream infections and <1% in other specimens. Among the anti-pseudomonal agents, piperacillin/tazobactam looks promising with highest susceptibility of 80%, followed by carbapenems which was 75%. Notably, isolates from ICU showed higher resistance rates compared to isolates non-ICU settings. Among the carbapenem resistant (CR) isolates, piperacillin/tazobactam and colistin have better activity than other agents. Hence, these two agents could be of better choice for the management of infections due to CR-*P. aeruginosa*. Though combinations are generally preferred for the management of pseudomonal infections, piperacillin/tazobactam, carbapenems, amikacin and colistin could be of superior choice.

Acinetobacter baumannii

Acinetobacter baumannii is resistant to most of the antibiotics tested (>70% approx.) except to colistin. Among the various specimens tested against different classes of antibiotics, resistance rates are higher among the invasive specimens like LRT, blood and CSF (>80%). Cephalosporins like cefepime and ceftazidime shows higher resistance rates (>70%) across all the specimens followed by amikacin (>65%), piperacillin-tazobactam (60%) and levofloxacin (55%). Among carbapenems, imipenem shows increased resistance of >85% whereas meropenem shows 80%. This scenario clearly indicates that monotherapy with carbapenems are not considered to be the choice of treatment for *A. baumannii* infections. Resistance to minocycline is around 40%, therefore combination therapy with meropenem or colistin can be considered. Empirical therapy is common among the ICU patients, therefore resistance rates against various antibiotics are higher among the ICU (>90%) when compared to ward and OPD. Also, resistance rates of different classes of antibiotics are higher among the carbapenem resistant *A. baumannii* compared to carbapenem susceptible *A. baumannii*.

Other NFGNB

B. cepacia shows increased resistance rates to trimethoprim-sulfamethoxazole followed by ceftazidime.Meropenem and minocycline can be considered as choice of treatment for infections caused by *B. cepacia*. *Stenotrophomonas maltophilia* is one among the non-fermenting gram negative bacilli causing severe infections. High rates of susceptibility is seen for ceftazidime, chloramphenicol, ticarcillin/clavulanic acid and trimethoprim/sulfamethoxazole. While, 5-10% of resistance is noted for levofloxacin and minocycline.

Table 5.1: Isolation rates of different NFGNB from different specimens.

Isolate	Culture positive																	
	Total n=45930		Blood n=9427		Urine n=7282		LRT n=5122		Pus n=14294		CSF n=435		SS n=1177		Faeces n=478		Others n=7715	
	n	%	n	%	N	%	n	%	n	%	n	%	n	%	n	%	n	%
No. culture positive	45930 (100)	100	9427 (100)	20.5	7282 (100)	15.9	5122 (100)	11.2	14294 (100)	31.1	435 (100)	0.9	1177 (100)	2.6	478 (100)	1	7715 (100)	16.8
NFGNB	12642 (27.5)	100	1792 (19)	14.2	599 (8.2)	4.7	3123 (61)	24.7	3385 (23.7)	26.8	174 (40)	1.4	322 (27.4)	2.5	5 (1)	0	3242 (42)	25.6
Pseudomonas	6465 (14.1)	100	554 (5.9)	8.6	448 (6.2)	6.9	1702 (33.2)	26.3	2026 (14.2)	31.3	63 (14.5)	1	148 (12.6)	2.3	3 (0.6)	0	1521 (19.7)	23.5
Pseudomonas aeruginosa	6465 (14.1)	100	554 (5.9)	8.6	448 (6.2)	6.9	1702 (33.2)	26.3	2026 (14.2)	31.3	63 (14.5)	1	148 (12.6)	2.3	3 (0.6)	0	1521 (19.7)	23.5
Acinetobacter	5885 (12.8)	100	1112 (11.8)	18.9	144 (2)	2.4	1374 (26.8)	23.3	1325 (9.3)	22.5	103 (23.7)	1.8	157 (13.3)	2.7	2 (0.4)	0	1668 (21.6)	28.3
Acinetobacter baumannii	3687 (8)	100	523 (5.5)	14.2	84 (1.2)	2.3	613 (12)	16.6	1077 (7.5)	29.2	56 (12.9)	1.5	71 (6)	1.9	2 (0.4)	0.1	1261 (16.3)	34.2

Acinetobacter calcoaceticus	**631 (1.4)**	**100**	**247 (2.6)**	**39.1**	**0 (0)**	**0**	**166 (3.2)**	**26.3**	**2 (0)**	**0.3**	**3 (0.7)**	**0.5**	**32 (2.7)**	**5.1**	**0 (0)**	**0**	**181 (2.3)**	**28.7**
Acinetobacter lwoffii	**243 (0.5)**	**100**	**40 (0.4)**	**16.5**	**6 (0.1)**	**2.5**	**6 (0.1)**	**2.5**	**95 (0.7)**	**39.1**	**10 (2.3)**	**4.1**	**13 (1.1)**	**5.3**	**0 (0)**	**0**	**73 (0.9)**	**30**
Acinetobacter spp.	**1324 (2.9)**	**100**	**302 (3.2)**	**22.8**	**54 (0.7)**	**4.1**	**589 (11.5)**	**44.5**	**151 (1.1)**	**11.4**	**34 (7.8)**	**2.6**	**41 (3.5)**	**3.1**	**0 (0)**	**0**	**153 (2)**	**11.6**
Stenotrophomonas maltophilia	**165 (0.4)**	**100**	**54 (0.6)**	**32.7**	**4 (0.1)**	**2.4**	**32 (0.6)**	**19.4**	**21 (0.1)**	**12.7**	**8 (1.8)**	**4.8**	**8 (0.7)**	**4.8**	**0 (0)**	**0**	**38 (0.5)**	**23**
Burkholderia cepacia	**127 (0.3)**	**100**	**72 (0.8)**	**56.7**	**3 (0)**	**2.4**	**15 (0.3)**	**11.8**	**13 (0.1)**	**10.2**	**0 (0)**	**0**	**9 (0.8)**	**7.1**	**0 (0)**	**0**	**15 (0.2)**	**11.8**

Acinetobacter baumanii

Table 5.2: Resistance percentages of *Acinetobacter baumannii* isolated from different specimen (except faeces).

AMA	Blood	LRT	Pus	CSF	Urine
	n=517	n=1443	n=1058	n=55	n=82
Amikacin	357/478 (74.7)	1208/1420 (85.1)	748/1041 (71.9)	44/54 (81.5)	54/82 (65.9)
Cefepime	403/475 (84.8)	1290/1405 (91.8)	853/1024 (83.3)	43/52 (82.7)	56/80 (70)
Ceftazidime	398/472 (84.3)	1239/1354 (91.5)	804/981 (82)	45/52 (86.5)	57/79 (72.2)
Colistin	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)
Imipenem	385/503 (76.5)	1211/1411 (85.8)	802/1038 (77.3)	39/54 (72.2)	50/81 (61.7)
Levofloxacin	261/451 (57.9)	916/1324 (69.2)	426/901 (47.3)	26/46 (56.5)	44/80 (55)
Meropenem	358/497 (72)	1133/1401 (80.9)	706/1008 (70)	35/54 (64.8)	46/80 (57.5)
Minocycline	65/177 (36.7)	225/523 (43)	49/344 (14.2)	*3/12 (-)	9/34 (26.5)
Piperacillin-tazobactam	362/470 (77)	1172/1335 (87.8)	768/993 (77.3)	41/52 (78.8)	49/82 (59.8)

Table 5.2.1: Resistance pattern of *Acinetobacter baumannii* isolated in different health care areas from all specimen (except faeces).

AMA	Total n=1313	OPD n=144	Ward n=690	ICU n=479
	(R%)	(R%)	(R%)	(R%)
Amikacin	953/1262 (75.5)	98/140 (70)	476/664 (71.7)	379/458 (82.8)
Cefepime	1052/1226 (85.8)	103/137 (75.2)	538/648 (83)	411/441 (93.2)
Ceftazidime	933/1097 (85.1)	91/126 (72.2)	481/583 (82.5)	361/388 (93)
Colistin	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)
Imipenem	961/1244 (77.3)	94/138 (68.1)	488/660 (73.9)	379/446 (85)
Levofloxacin	679/1070 (63.5)	74/123 (60.2)	324/555 (58.4)	281/392 (71.7)
Meropenem	904/1237 (73.1)	85/138 (61.6)	462/658 (70.2)	357/441 (81)
Minocycline	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)
Piperacillin-tazobactam	855/1086 (78.7)	82/124 (66.1)	441/579 (76.2)	332/383 (86.7)

Table 5..2.2: Resistance pattern of Carbapenem-resistant and susceptible records for *Acinetobacter* isolated from all (except faeces) specimens.

AMA	CR n=1438	CS n=683
Amikacin	1303/1431 (91.1)	286/661 (43.3)
Cefepime	1189/1207 (98.5)	315/584 (53.9)
Ceftazidime	1295/1322 (98)	299/600 (49.8)
Colistin	*0/0 (-)	*0/0 (-)
Imipenem	1313/1431 (91.8)	189/674 (28)
Levofloxacin	1016/1288 (78.9)	251/591 (42.5)
Meropenem	1434/1434 (100)	0/666 (0)
Minocycline	*0/0 (-)	*0/0 (-)
Piperacillin-tazobactam	1177/1245 (94.5)	224/620 (36.1)
Imipenem / Meropenem / Ertapenem	1438/1438 (100)	189/1438 (27.7)

Pseudomonas aeruginosa

Table 5.3: Resistance percentages of *Pseudomonas aeruginosa* isolated from different specimen (except faeces).

AMA	Blood	LRT	Pus	CSF	Urine
	n=545	n=2526	n=1980	n=61	n=430
Amikacin	172/542 (31.7)	648/2525 (25.7)	584/1969 (29.7)	29/57 (50.9)	231/430 (53.7)
Cefepime	162/442 (36.7)	732/2184 (33.5)	621/1790 (34.7)	32/57 (56.1)	222/418 (53.1)
Ceftazidime	175/527 (33.2)	735/2446 (30)	605/1895 (31.9)	29/61 (47.5)	207/427 (48.5)
Ciprofloxacin	143/416 (34.4)	703/1931 (36.4)	792/1956 (40.5)	38/58 (65.5)	251/424 (59.2)
Colistin	8/193 (4.1)	7/852 (0.8)	3/750 (0.4)	0/30 (0)	2/229 (0.9)
Gentamicin	143/347 (41.2)	586/1460 (40.1)	674/1743 (38.7)	32/52 (61.5)	245/425 (57.6)
Imipenem	159/536 (29.7)	610/2435 (25.1)	323/1959 (16.5)	22/56 (39.3)	122/425 (28.7)
Levofloxacin	167/497 (33.6)	824/2383 (34.6)	729/1818 (40.1)	40/58 (69)	253/418 (60.5)
Meropenem	150/496 (30.2)	652/2229 (29.3)	391/1742 (22.4)	27/59 (45.8)	195/426 (45.8)
Piperacillin-tazobactam	112/508 (22)	514/2435 (21.1)	386/1890 (20.4)	18/56 (32.1)	133/426 (31.2)
Tobramycin	128/393 (32.6)	595/2145 (27.7)	539/1622 (33.2)	28/49 (57.1)	197/334 (59)

Table 5.3.1: Resistance pattern of *Pseudomonas aeruginosa* isolated in different health care areas from all specimen (except faeces).

AMA	Total n=2222	OPD n=584	Ward n=1185	ICU n=453
	(R%)	(R%)	(R%)	(R%)
Amikacin	726/2182 (33.3)	145/575 (25.2)	375/1166 (32.2)	206/441 (46.7)
Cefepime	780/2008 (38.8)	137/520 (26.3)	430/1076 (40)	213/412 (51.7)
Ceftazidime	771/2043 (37.7)	134/526 (25.5)	434/1106 (39.2)	203/411 (49.4)
Ciprofloxacin	871/1908 (45.6)	198/499 (39.7)	442/997 (44.3)	231/412 (56.1)
Colistin	18/1629 (1.1)	1/418 (0.2)	11/855 (1.3)	6/356 (1.7)
Gentamicin	764/1620 (47.2)	157/402 (39.1)	382/852 (44.8)	225/366 (61.5)
Imipenem	473/2157 (21.9)	65/562 (11.6)	250/1155 (21.6)	158/440 (35.9)
Levofloxacin	872/1905 (45.8)	187/485 (38.6)	457/1035 (44.2)	228/385 (59.2)
Meropenem	611/1894 (32.3)	91/469 (19.4)	327/1030 (31.7)	193/395 (48.9)
Piperacillin-tazobactam	493/2040 (24.2)	92/536 (17.2)	269/1093 (24.6)	132/411 (32.1)
Tobramycin	742/1904 (39)	152/488 (31.1)	385/1027 (37.5)	205/389 (52.7)

Table 5.3.2: Resistance pattern of Carbapenem-resistant and susceptible records for *Pseudomonas aeruginosa* isolated from all (except faeces) specimens.

AMA	CR n=658	CS n=1520
Amikacin	469/653 (71.8)	256/1491 (17.2)
Cefepime	476/630 (75.6)	302/1347 (22.4)
Ceftazidime	450/606 (74.3)	320/1404 (22.8)
Ciprofloxacin	509/568 (89.6)	360/1328 (27.1)
Colistin	15/514 (2.9)	3/1109 (0.3)
Gentamicin	445/513 (86.7)	319/1104 (28.9)
Imipenem	409/654 (62.5)	64/1503 (4.3)
Levofloxacin	525/584 (89.9)	343/1295 (26.5)
Meropenem	611/611 (100)	0/1283 (0)
Piperacillin-tazobactam	305/605 (50.4)	186/1401 (13.3)
Tobramycin	470/609 (77.2)	272/1267 (21.5)
Imipenem / Meropenem / Ertapenem	658/658 (100)	64/658 (4.2)

Burkholderia cepacia

Table 5.4: Resistance percentages of *Burkholderia cepacia* isolated from different specimen (except faeces).

AMA	All Specimens (except faeces)	Blood	LRT	Pus
	n=126	n=72	n=23	n=*13
Ceftazidime	28/110 (25.5)	12/61 (19.7)	9/23 (39.1)	*2/10 (-)
Chloramphenicol	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)
Levofloxacin	*3/11 (-)	*3/7 (-)	*0/2 (-)	*0/1 (-)
Meropenem	21/121 (17.4)	10/71 (14.1)	6/22 (27.3)	*0/11 (-)
Minocycline	8/117 (6.8)	2/67 (3)	4/22 (18.2)	*2/13 (-)
Ticarcillin-clavulanic acid	*7/7 (-)	*4/4 (-)	*2/2 (-)	*0/0 (-)
Trimethoprim-sulfamethoxazole	32/114 (28.1)	21/68 (30.9)	5/22 (22.7)	*2/10 (-)

Stenotrophomonas maltophilia

Table 5.5: Resistance percentages of *Stenotrophomonas maltophilia* isolated from different specimen (except faeces).

AMA	All Specimens (except faeces)	Blood	LRT	Pus
	n=161	n=53	n=54	n=21
Ceftazidime	*7/17 (-)	*3/5 (-)	*1/6 (-)	*0/0 (-)
Chloramphenicol	*0/0 (-)	*0/0 (-)	*0/0 (-)	*0/0 (-)
Levofloxacin	22/156 (14.1)	8/52 (15.4)	6/51 (11.8)	1/20 (5)
Minocycline	6/158 (3.8)	1/53 (1.9)	2/53 (3.8)	1/21 (4.8)
Ticarcillin-clavulanic acid	*6/17 (-)	*3/5 (-)	*0/6 (-)	*0/0 (-)
Trimethoprim-sulfamethoxazole	35/139 (25.2)	9/43 (20.9)	14/48 (29.2)	*0/19 (-)

6. *Enterobacteriaceae spp.*

Of the 19,619 isolates of *Enterobacteriaceae, E. coli* constituted 49% followed by *Klebsiella pneumoniae* (35%). E. coli accounted for two thirds of urinary isolates whereas *Klebsiella pneumoniae* accounted for two thirds of the isolates from LRT. Specimen wise E. coli followed by *Klebsiella pneumoniae* pattern was found in isolates from blood (46%, 42%), urine (67%, 24%), pus (47%, 31%), surgical site (48%, 37%) and faeces (70%, 16%) while the reverse, *Klebsiella pneumoniae* followed by E. coli pattern was found in isolates from LRT (66%, 23%) and CSF (44%, 38%). The third common species was *Enterobacter* species constituting 7% overall (13% of CSF and 10% of surgical site) and *Proteus* species constituting 5% overall (8% of pus). Strict surveillance for prevalence of isolates of *Proteus, Providencia* and *Morganella* species is indicated because of their emerging potential consequent with increasing use of colistin, due to their intrinsic resistance to the same. Of the *Enterobacteriaceae, E. coli* was the commonest (46%) followed by *K. pneumoniae* (42%) and *Enterobacter* species (7%).

Table 6.1. Genera of *Enterobacteriaceae* specimen wise.

	Blood	Urine	LRT	Pus	CSF	SS	Feces	Others	Total
E. coli	1619	3586	398	2591	65	261	30	1052	9602
Citrobacter	55	99	29	137	4	4	1	56	385
Enterobacter	258	216	116	475	22	57	2	226	1372
Klebsiella	1497	1270	1143	1685	76	200	7	1075	6953
Morganella	11	26	5	60	0	3	0	37	142
Proteus	39	108	26	456	1	16	3	273	922
Providencia	11	14	4	51	2	2	0	50	134
Serratia	38	8	19	17	1	1	0	25	109
Total	3528	5327	1740	5472	171	544	43	2794	19619

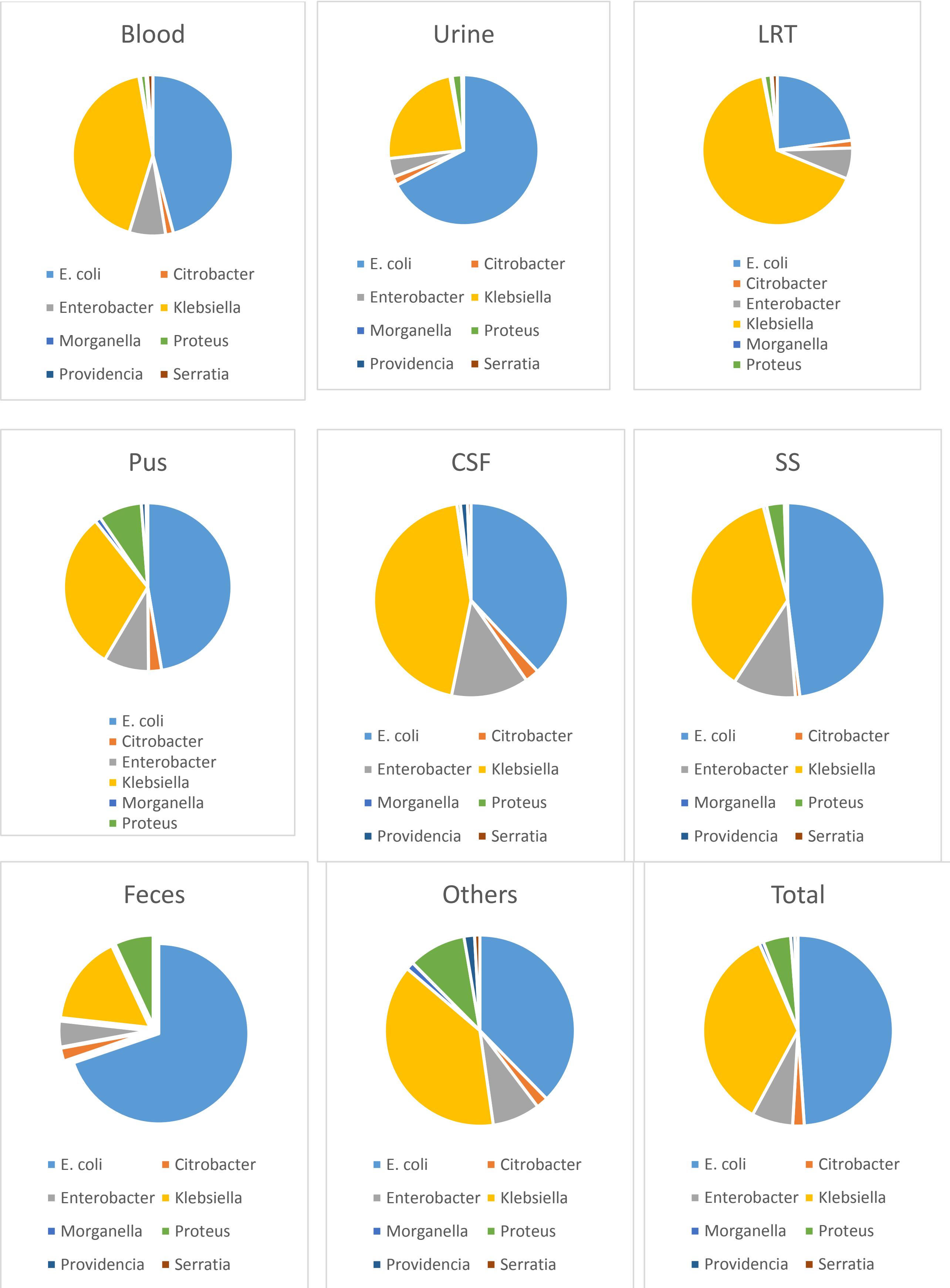
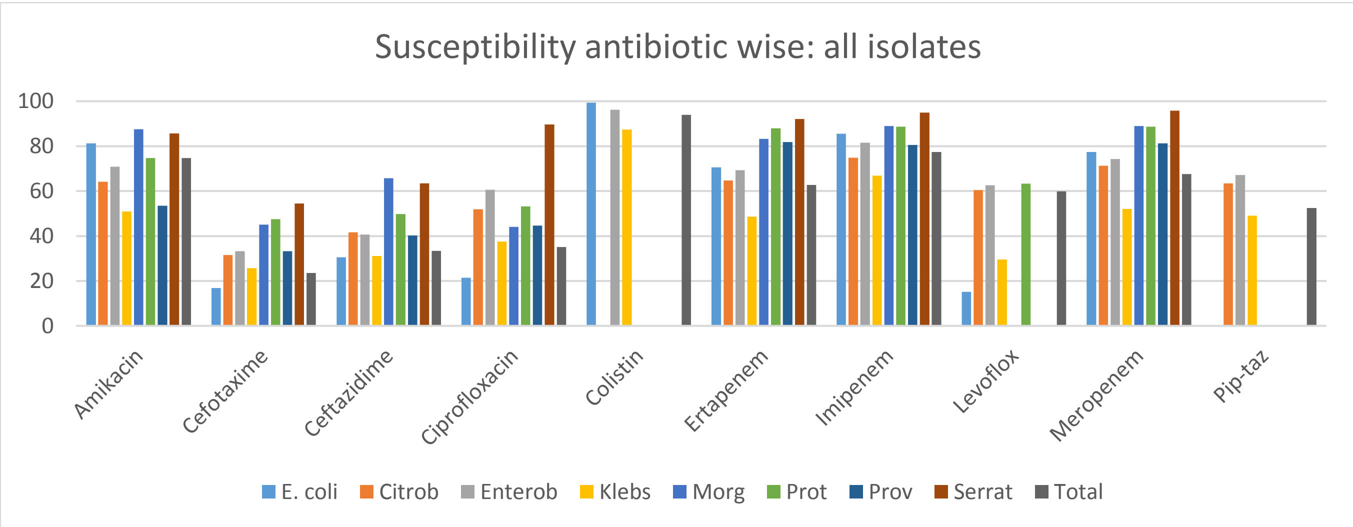


Figure 6.0 . Distribution of genera of *Enterobacteriaceae* specimen wise.

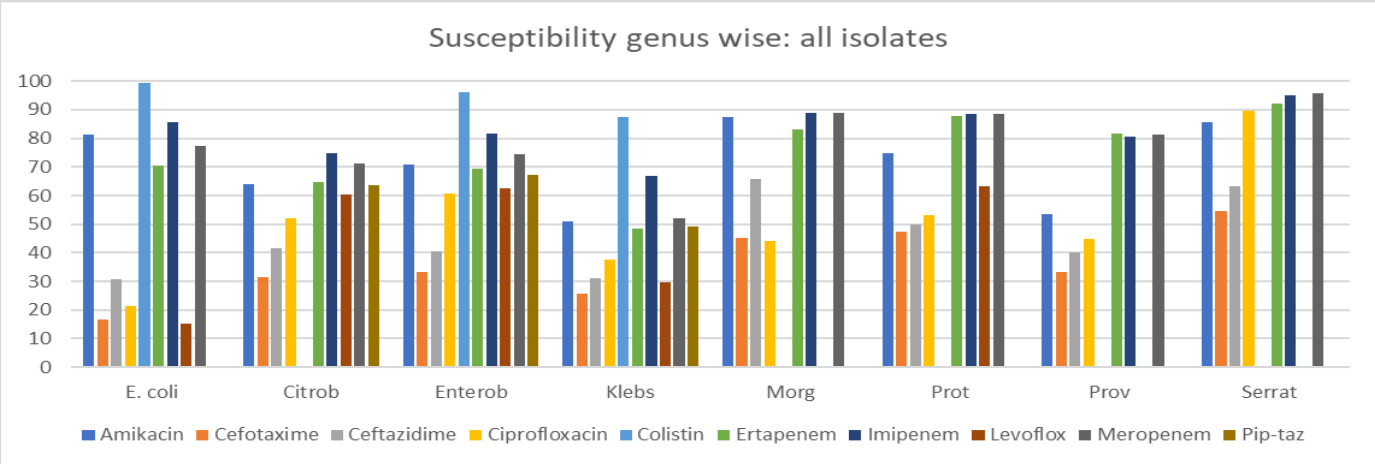
Overall, the isolates of *Enterobacteriaceae* showed best susceptibility to colistin (94%) followed by imipenem (77%) and amikacin (75%). Moderate susceptibility was shown to meropenem (68%), ertapenem (63%), levofloxacin (60%) and piperacillin-tazobactam (52%). Poor susceptibility was found against cefotaxime (24%), ceftazidime (33%) and ciprofloxacin (35%). Against colistin maximum susceptibility was shown by E. coli (99%) followed by *Enterobacter* (96%), with least susceptibility by *Klebsiella pneumoniae* (87%). Against imipenem, good susceptibility was shown by *Serratia* (97%), *Proteus* (89%), *Providencia* (81%), *Morganella* (89%) and *E. coli* (86%) while least susceptibility was shown by *Klebsiella* (67%). While meropenem showed comparable susceptibility in *Serratia, Proteus, Providencia and Morganella* species, its efficacy was poorer than imipenem against *E. coli* and *Klebsiella* species. Only half of the isolates were susceptible to piperacillin-tazobactam. *Klebsiella* species were the most resistant with only colistin and imipenem showing good susceptibility. *Serratia, Proteus, Providencia* and *Morganella* species showed good (≥ 80%) susceptibility to all the carbapenems and amikacin. E. coli showed good susceptibility to amikacin, carbapenems and colistin.

Figure 6.1 . Antibiotic wise susceptibility of genera of Enterobacteriaceae from all specimens.



The blood isolates reflected the same general pattern of susceptibility except *E. coli* showing 72% susceptibility to piperacillin-tazobactam. Amongst urinary isolates phosphomycin showed 84% susceptibility for E. coli. Nitrofurantoin susceptibility was good for *E. coli*(83%) and *Citrobacter* species (85%) but poor for *Klebsiella*(48%) species and *Enterobacter* species (45%). For most of the species cotrimoxazole susceptibility was less than 50%>.

Figure 6.2 . Genus wise susceptibility of *Enterobacteriaceae* to various antibiotics.



Enterobacteriaceae from blood showed maximum susceptibility to colistin, followed by imipenem, meropenem, ertapenem, piperacillin-tazobactam and amikacin. Third generation cephalosporins, including cefotaxime and ceftazidime, showed susceptibility of less than 30%. Genus wise, *Klebsiella* species showed the maximum resistance, followed by *Citrobacter and Proteus* species.

Figure 6.3 . Antibiotic wise susceptibility of genera of Enterobacteriaceae from blood.

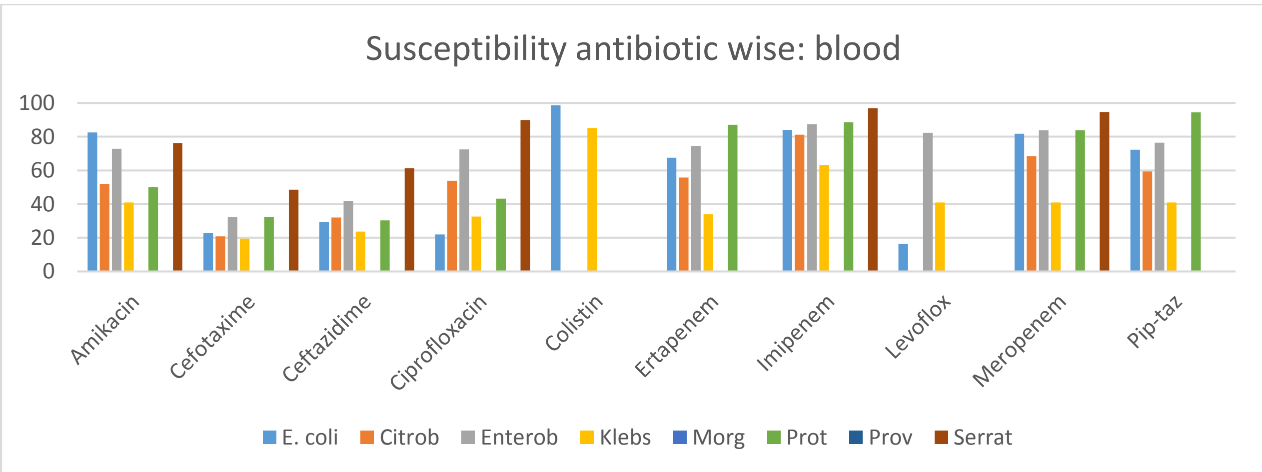


Figure 6.4 . Genus wise susceptibility of Enterobacteriaceae isolated from blood to various antibiotics.

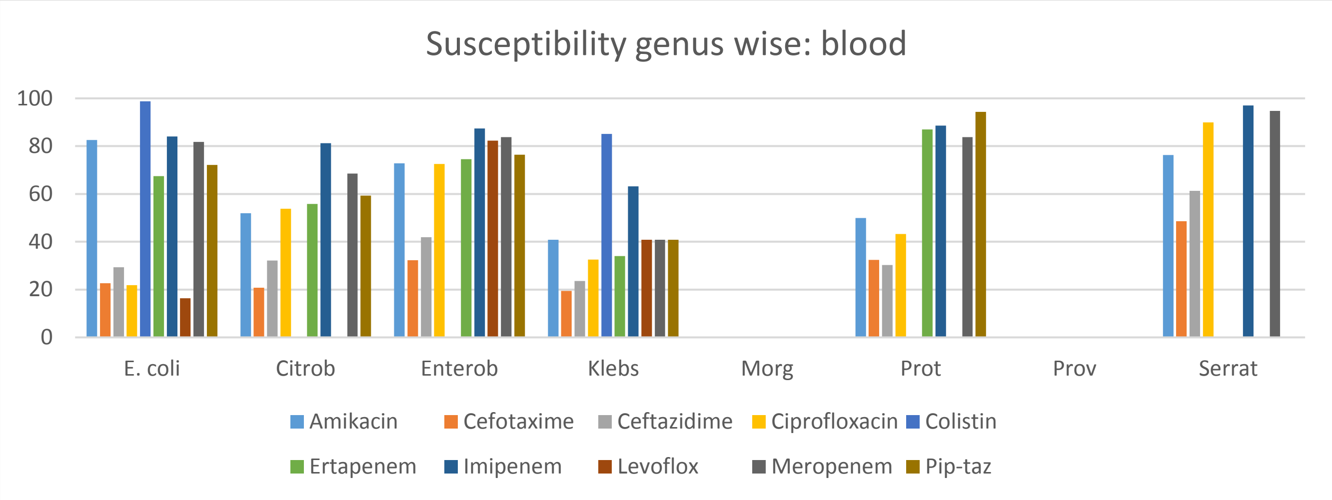


Table 6.2. Antibiotic susceptibility of Enterobacteriaceae from blood, genus wise. NI: number insufficient (<30).

	E. coli	Citrobacter	Entero bacter	Klebsiella	Morganella	Proteus	Providence	Serratia
Amikacin	83	52	73	41	NI	50	NI	76
Cefotaxime	23	21	32	19	NI	32	NI	49
Ceftazidime	29	32	42	24	NI	30	NI	61
Ciprofloxacin	22	54	73	33	NI	43	NI	90
Colistin	99	NI	NI	85	NI	NI	NI	NI
Ertapenem	68	56	75	34	NI	87	NI	NI
Imipenem	84	81	87	63	NI	89	NI	97
Levoflox	16	NI	82	41	NI	NI	NI	NI
Meropenem	82	69	84	41	NI	84	NI	95
Pip-taz	72	59	76	41	NI	94	NI	NI

Enterobacteriaceae from urine showed maximum susceptibility to colistin, followed by imipenem, meropenem, ertapenem, piperacillin-tazobactam, amikacin, levofloxacin and nitrofurantoin. Third generation cephalosporins, including cefotaxime and ceftazidime, showed susceptibility of less than 30% (except *Citrobacter* and *Proteus* species). Genus wise, *Klebsiella* species showed the maximum resistance, followed by *Enterobacter* and *Proteus* species.

Figure 6.3. Antibiotic wise susceptibility of genera of *Enterobacteriaceae* from urine.

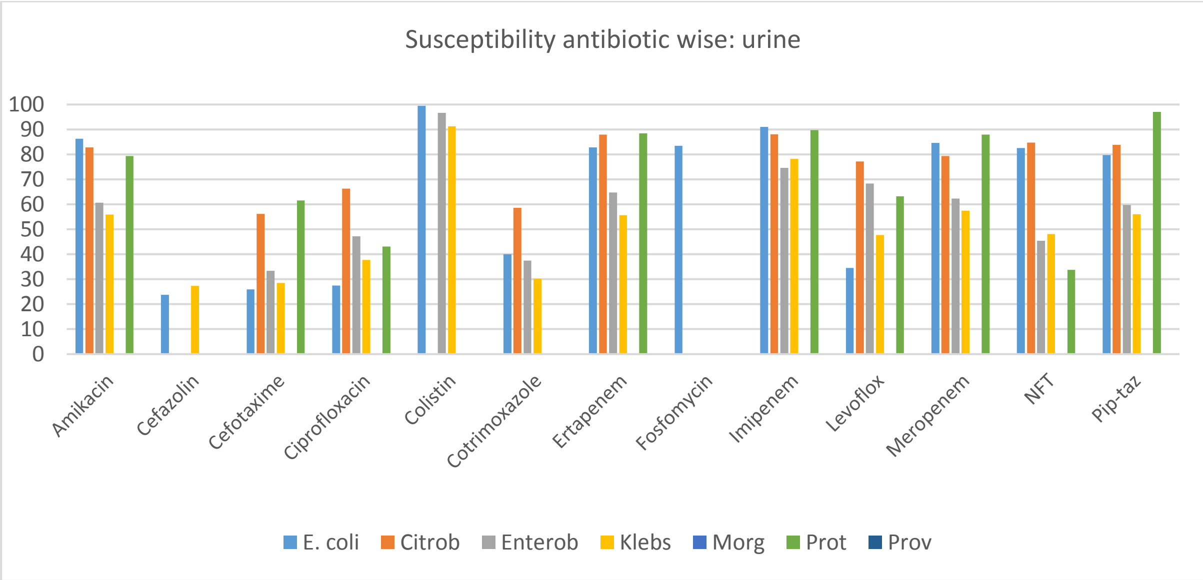


Figure 6.4. Genus wise susceptibility of *Enterobacteriaceae* isolated from urine to various antibiotics.

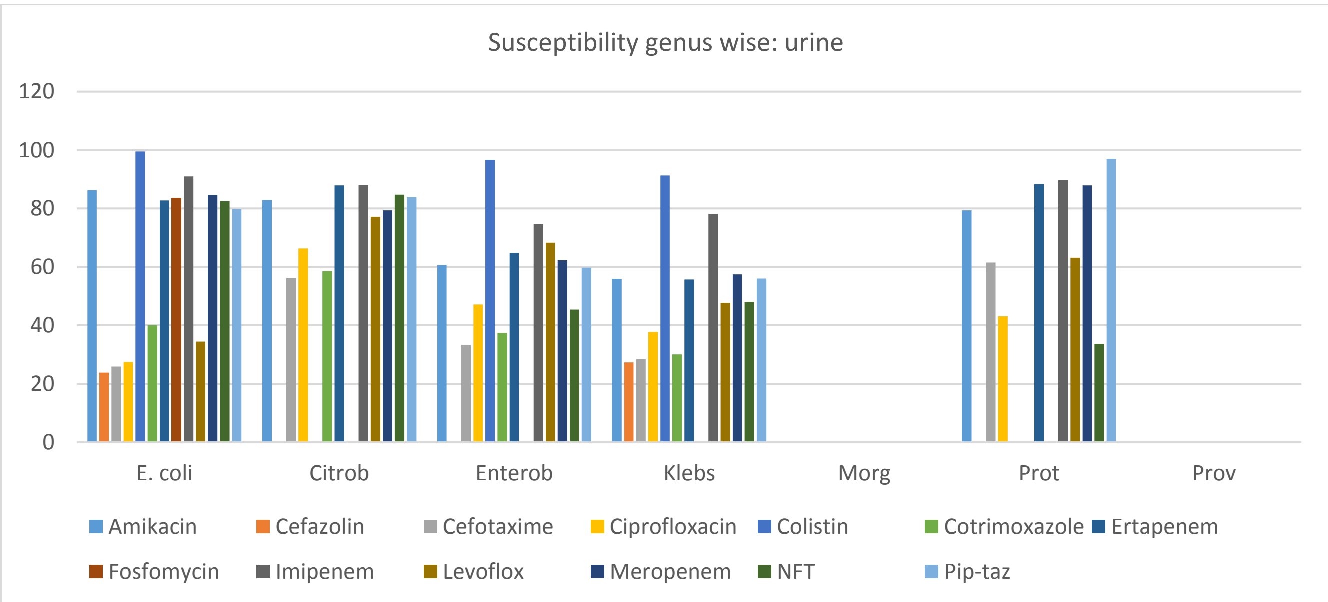


Table 6.3 . Antibiotic susceptibility of *Enterobacteriaceae* from urine, genus wise. NI: number insufficient (<30).

	E. coli	Citrob	Enterob	Klebs	Morg	Prot	Prov
Amikacin	86	83	61	56	NI	79	NI
Cefazolin	24			27		NI	
Cefotaxime	26	56	33	28	NI	62	NI
Ciprofloxacin	28	66	47	38	NI	43	NI
Colistin	100	NI	97	91	NI		NI
Cotrimoxazole	40	59	37	30	NI	NI	
Ertapenem	83	88	65	56	NI	88	NI
Fosfomycin	84						
Imipenem	91	88	75	78	NI	90	NI
Levoflox	35	77	68	48	NI	63	NI
Meropenem	85	79	62	57	NI	88	NI
NFT	83	85	45	48	NI	34	
Pip-taz	80	84	60	56	NI	97	NI