National Antimicrobial Resistance Surveillance Network (NARS-Net India)

AMR Annual report -2020

Reporting Period - January to December 2019

National Programme on AMR Containment
National Centre for Disease Control
Directorate General of Health Services, Ministry of Health and Family Welfare
Government of India

National Antimicrobial Resistance Surveillance Network (NARS-Net India)

Annual report

January to December 2019

Contents

A. Acronyms

AMR	Antimicrobial Resistance Surveillance
AST	Antimicrobial Susceptibility Testing
BMD	Broth Microdilution
EQAS	External Quality Assessment Scheme
GLASS	Global Antimicrobial Resistance Surveillance System
IPD	In-patient
ICU	Intensive care unit
IQC	Internal Quality Control
LIMS	Laboratory Information Management System
MRSA	Methicillin Resistant *S. aureus*
NARS-Net	National AMR Surveillance Network
NFGNB	Non-fermenting Gram-negative bacilli
NRL	National Reference Laboratory
OPD	Outpatient
OSBF	Other Sterile Body Fluids
PA	Pus aspirate
R	Resistant
R I S	Resistant Intermediate Sensitive
SOP	Standard Operating Procedure
WHO	World Health Organization

B. List of Tables :

C. List of Figures:

I. Executive Summary

Under the National AMR Surveillance Network, during the year 2019 National Centre for Disease Control received AMR Surveillance data from 21 sentinel surveillance laboratories located in 19 different States. A total of 78,860 priority pathogens and their antimicrobial sensitivity data from 74,200 unique patients have been reported. Of these 74,200 isolates, 45% are from urine, 33% from pus aspirates & other sterile body fluids and 22% from blood. *E. coli* constitutes the highest number of isolates (33%) in the AMR surveillance data of the year 2019 followed by *Klebsiella* spp. (22%), *S. aureus* (18%), *Pseudomonas* spp. (10%), *Enterococcus* spp. (9%), *Acinetobacter* spp. (8%) and *Salmonella* Typhi and Paratyphi (< 1%).

Among outpatients and inpatients, *E. coli* is the commonest pathogen isolated while *Klebsiella* spp. is the commonest pathogen isolated in ICU patients. Higher rates of resistance are seen in ICU settings for most of the antibiotics.

Sixty-six percent resistance is seen for cefoxitin, surrogate marker for methicillin resistant *S. aureus* (MRSA). In addition, 1% resistance is seen in *S. aureus* and 5% in *Enterococcus* spp. to linezolid and 13% resistance to vancomycin in *Enterococcus* spp. Resistance to these last resort drugs for treating Gram-positive cocci is a matter of concern.

Among gram negative bacteria (*E. coli*, *Klebsiella* spp.) reported under NARS-Net, 80% and 60% of the blood isolates were resistant to 3rd and 4th generation cephalosporins respectively. High level resistance to carbapenems is seen in *Klebsiella* spp. and *E. coli*. Five percent of *Klebsiella* spp. isolated from blood of ICU patients are colistin resistant.

Piperacillin/tazobactam is the most effective antibiotic for *Pseudomonas* spp. and Minocycline was most effective antibiotic for *Acinetobacter* spp. Eight percent colistin resistance is seen in both the non-fermenting gram-negative bacilli (*Pseudomonas* spp. and *Acinetobacter* spp.).

II. National Antimicrobial Resistance Surveillance Network (NARS-Net)

National Centre for Disease Control (NCDC) is coordinating the "National Programme on Antimicrobial resistance Containment" which was initiated during the 12th five-year plan (2012-2017). One of the goals of this Programme is to generate quality Antimicrobial Resistance (AMR) surveillance data in order to understand the AMR trends in various geographical regions through a sentinel surveillance platform. Under this programme a network of state medical college laboratories has been set up which is being expanded in a phased manner. The National Antimicrobial Resistance Surveillance Network (NARS-Net) currently includes 29 state medical college labs in 24 states. The AMR surveillance under this network presently includes seven priority bacterial pathogens isolated from 5 clinical samples

The seven priority pathogens included under the NARS-Net:

1. *Staphylococcus aureus*
2. *Enterococcus* spp.
3. *Escherichia coli*
4. *Klebsiella* spp.
5. *Salmonella enterica* serotype Typhi and Paratyphi
6. *Pseudomonas* spp.
7. *Acinetobacter* spp.

The clinical specimens currently included under NARS-Net:

- Blood
- Urine
- Aspirated pus
- Other sterile body fluids and
- Stool (only for *Salmonella* Typhi & Paratyphi)

The network sites are mandated to report emerging AMR alerts and send them for confirmation to National Reference Laboratory (NRL) at NCDC. In addition, the sites also send defined number of strains on a quarterly basis under External Quality Assessment Scheme (EQAS) being conducted by the NRL. In July 2017, NCDC has been designated by Ministry of Health and Family Welfare as National coordinating center for AMR surveillance in the country and for submission of country data onto WHO-Global Antimicrobial Resistance Surveillance System (GLASS). The AMR surveillance data submitted under the National programme on AMR Containment is validated by NCDC and the AMR trends are published in the form of annual report. The annual report for the AMR surveillance data of 2017 and 2018 is available on NCDC website.

The sentinel surveillance laboratories under NARS-Net follow a standardized approach for AMR data collection, analysis, and reporting of AMR surveillance data using WHONET data management software. Standard operating procedures (SOPs) and guidance documents have been developed for sentinel surveillance sites for AMR surveillance and the sites are trained to use these effectively in their day to day work. In addition, training is also provided on AMR data management using the WHONET software. Continuous support is provided to sites to improve the quality of specimen collection, bacterial culture, identification of pathogens & their antimicrobial susceptibility testing (AST) which includes provision of regular hands on training and onsite support for streamlining AMR data management. Regular feedback is provided using a standardized data management tool to improve the AMR data quality.

As of 31st March 2020, the NARS-Net included 29 medical college laboratories located in 24 states (Annexure-1). In the year 2019 (01 January 2019 to 31 December 2019), bacteriology laboratories from 21 sentinel locations in 19 different States reported data to NCDC (Fig. A).

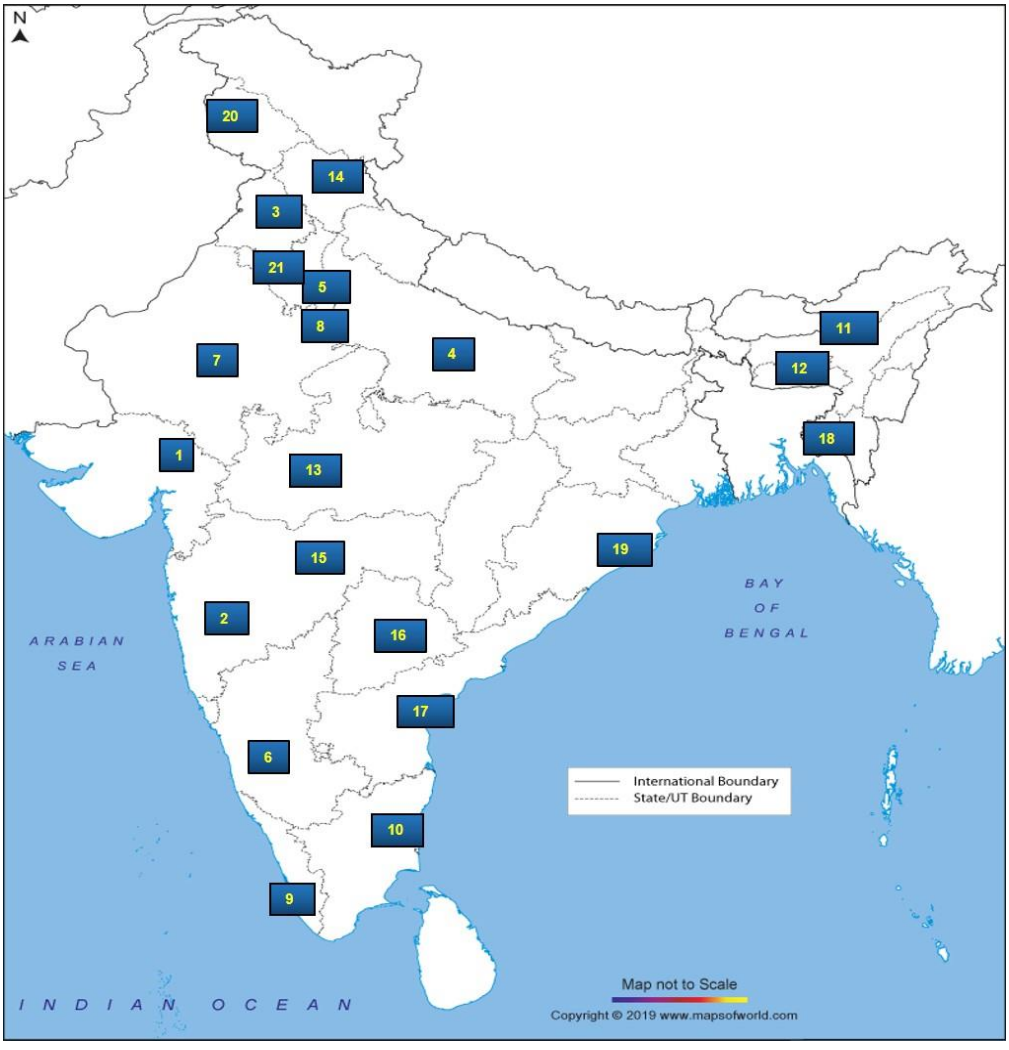

Fig. 1 National AMR Surveillance Network Laboratories that have reported AMR Surveillance data to NCDC in the year 2019 under NARS-Net (List at Annexure-1)

III. Data Collection and Analysis

Data of 78,860 priority pathogens and their antimicrobial sensitivity has been reported under NARS-Net during the year 2019. The laboratories having Laboratory information management systems (LIMS) and/ or automated AST systems are trained in back linking the data to WHONET. The data has been validated and analyzed at NCDC for preparation of National AMR Surveillance Annual Report for the year 2019.

All sentinel sites submitted the data quarterly after validation by AMR nodal officer at the sites. The data is to be submitted by the network sites within 15 days after each quarter:

- Data from January 1 to March 31 of the current year sent by 15th April
- Data from April 1 to June 30 of the current year sent by 15th July
- Data from July 1 to September 30 of the current year sent by 15th October
- Data from October 1 to December 31 of the previous year sent by 15th January

The sites are provided feedback on the data submitted and where required the sites are requested to re-submit the revised data. The sites also submit identified priority pathogens to the NRL at NCDC as a part of EQAS for confirmation of species identification and susceptibility testing following the standard protocols[1]. In addition, AMR alert strains as specified under the programme are also submitted by the sentinel sites to NRL for confirmation.

Onsite support visits and online trainings are conducted for handholding the sites for effective AMR surveillance data management. The validated quarterly AMR data in WHONET files received from network sites is stored and managed at NCDC in password-protected folders and after de-duplication imported into the nationwide database. The nationwide database is validated, and quality checked at NCDC, followed by analysis of data to develop the annual report.

[1] Guidance for submission of AMR Surveillance isolates for External Quality Assessment and Emerging AMR Alerts

IV. Data Deduplication

During analysis, data de-duplication has been done for data from each site at NCDC. In situations where several clinical specimens of same type have been reported for a unique patient by the reporting facility, de-duplication has been done to achieve one isolate per patient. Only one AST result has been considered for data analysis even though there might be different AST patterns observed during repeated isolation of same species from same specimen type i.e. AST result of the first isolate of a priority pathogen reported from the same specimen type of the patient during the hospital stay has been considered.

For example, if two blood cultures from the same patient yield growth of *E. coli*, only the first result is included in the data analysis; if growth of *E. coli* is detected in one culture and of *K. pneumoniae* in the other, both results are analyzed and reported. If there is growth of *E. coli* in one blood culture and in one urinary culture from the same patient, both specimen types are analyzed and reported.[2]

V. Priority Pathogens under surveillance in NARS -Net

Under the programme, the AMR data for the year 2019 has been submitted by 21 sentinel laboratories from Government Medical colleges/ tertiary healthcare settings in 19 states (S.no. 1 to 21 at Annexure 1). AMR surveillance data of a total of 78,860 isolates submitted under NARS-Net has been de-duplicated & analyzed and is summarized below:

Table 1 Pathogens and specimens included under surveillance

Specimen	*S. aureus*	*Enterococcus* spp.	*Klebsiella* spp.	*E. coli*	*Acinetobacter* spp.	*Pseudomonas* spp.	*Salmonella* Typhi/Paratyphi
Blood	●	●	●	●	●	●	●
Urine		●	●	●	●	●	
Pus Aspirates	●	●	●	●	●	●	
Other Sterile Body fluids	●	●	●	●	●	●	
Stool							●

[2] WHO Global Antimicrobial Surveillance System Manual for Early Implementation (2015)].

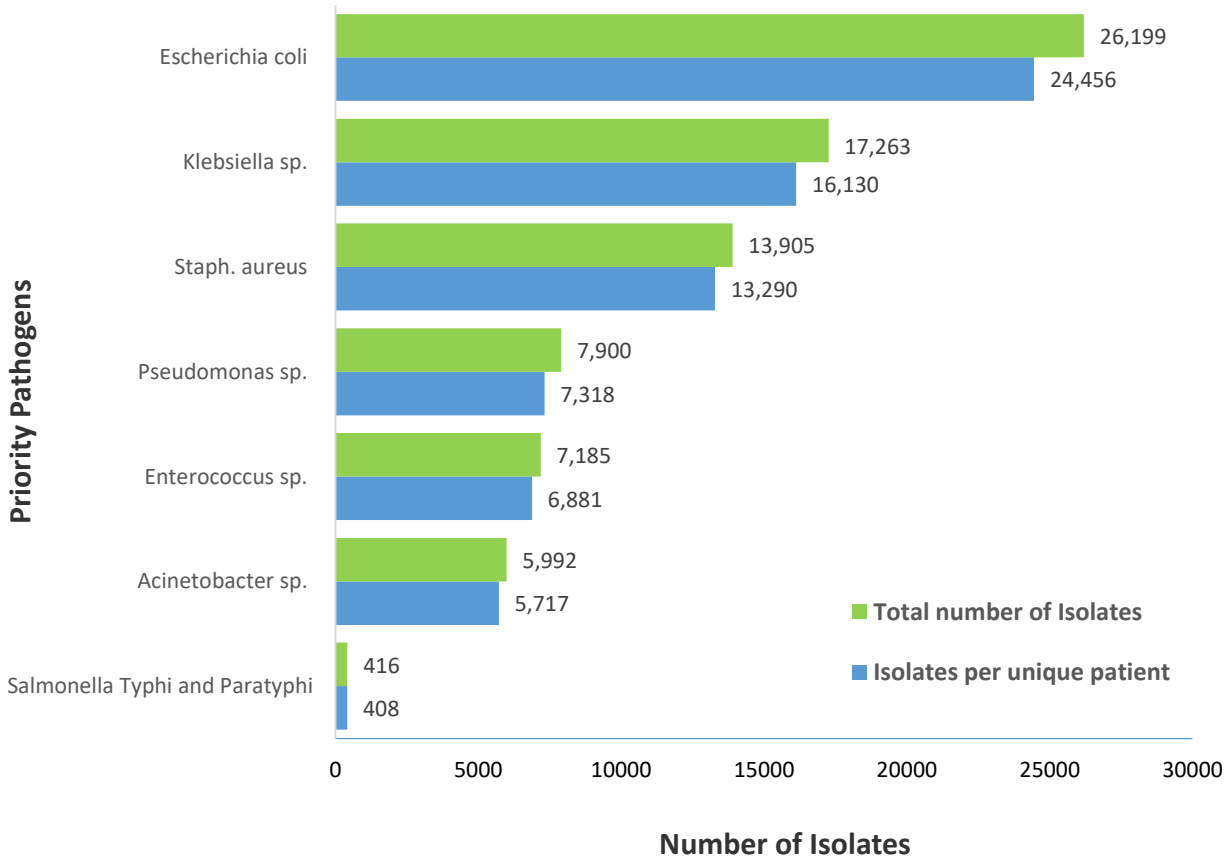

Fig. 2 Priority bacterial pathogens before and after de-duplication

Total number of isolates from unique patients (after de-duplication) = 74,200

- Urine - 33,642 (45%)
- Blood - 16,189 (22%)
- Pus Aspirates (PA) and Other Sterile body fluids (OSBF) - 24,368 (33%)
- Stool - 1

In the 2019 AMR surveillance data, *E. coli* (33%) is the most commonly isolated pathogen followed by *Klebsiella* spp. (22%), *S. aureus* (18%), *Pseudomonas* spp. (10%), *Enterococcus* spp. (9%) and *Acinetobacter* spp. (8%) and *Salmonella enterica* serovar Typhi and Paratyphi (0.5%). (Fig. 4) Highest number of isolates included in the data are from urine samples, followed by pus & other sterile body fluids and blood. (Fig. 3)

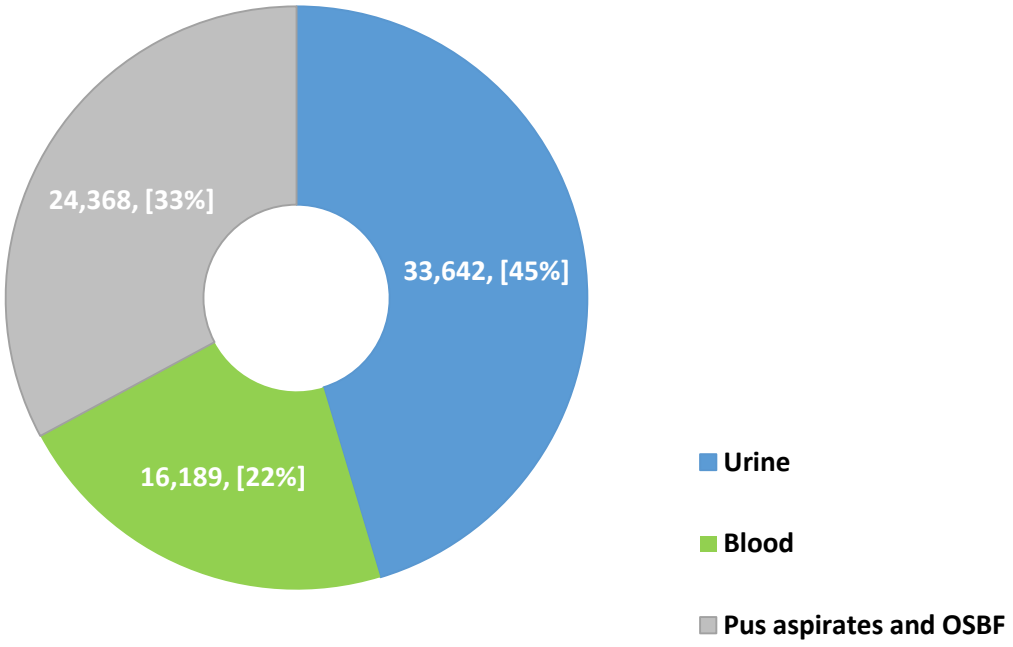

Fig. 3 Distribution of isolates by specimen type

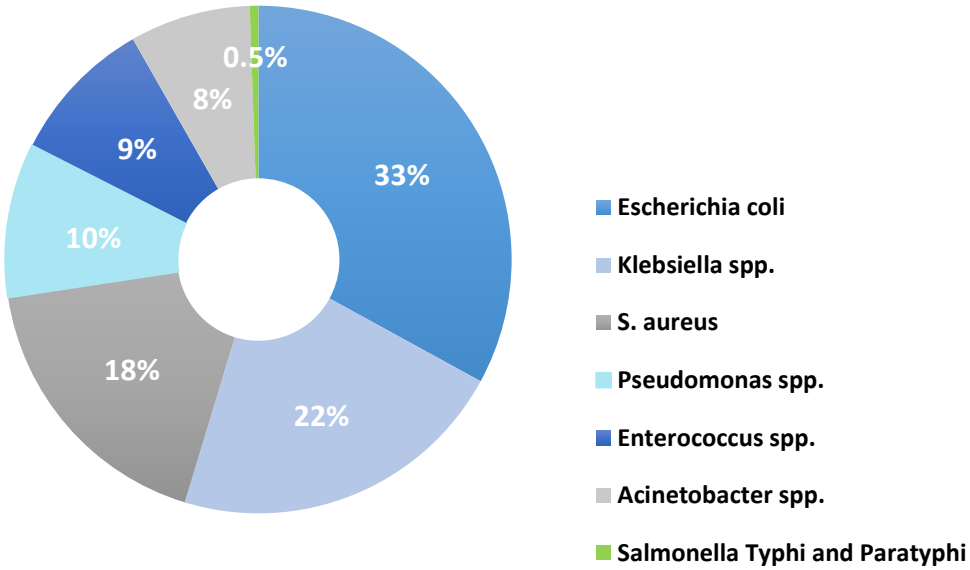

Fig. 4 Distribution of isolates

S. aureus (38%) is most commonly isolated pathogen in blood specimens followed by *Acinetobacter* spp. (19%) and *Klebsiella* spp. (18%) (Fig. 5). *E. coli* (55%) is the most commonly isolated pathogen in urine specimens followed by *Klebsiella* spp. (21%) and *Enterococcus* spp. (13%). *S. aureus* (34%) is the most frequently isolated pathogen from pus and other sterile body fluids followed by *Klebsiella* spp. (20%), *E. coli* (18%) and *Pseudomonas* spp. (15%). (Fig. 5 & Table 2)

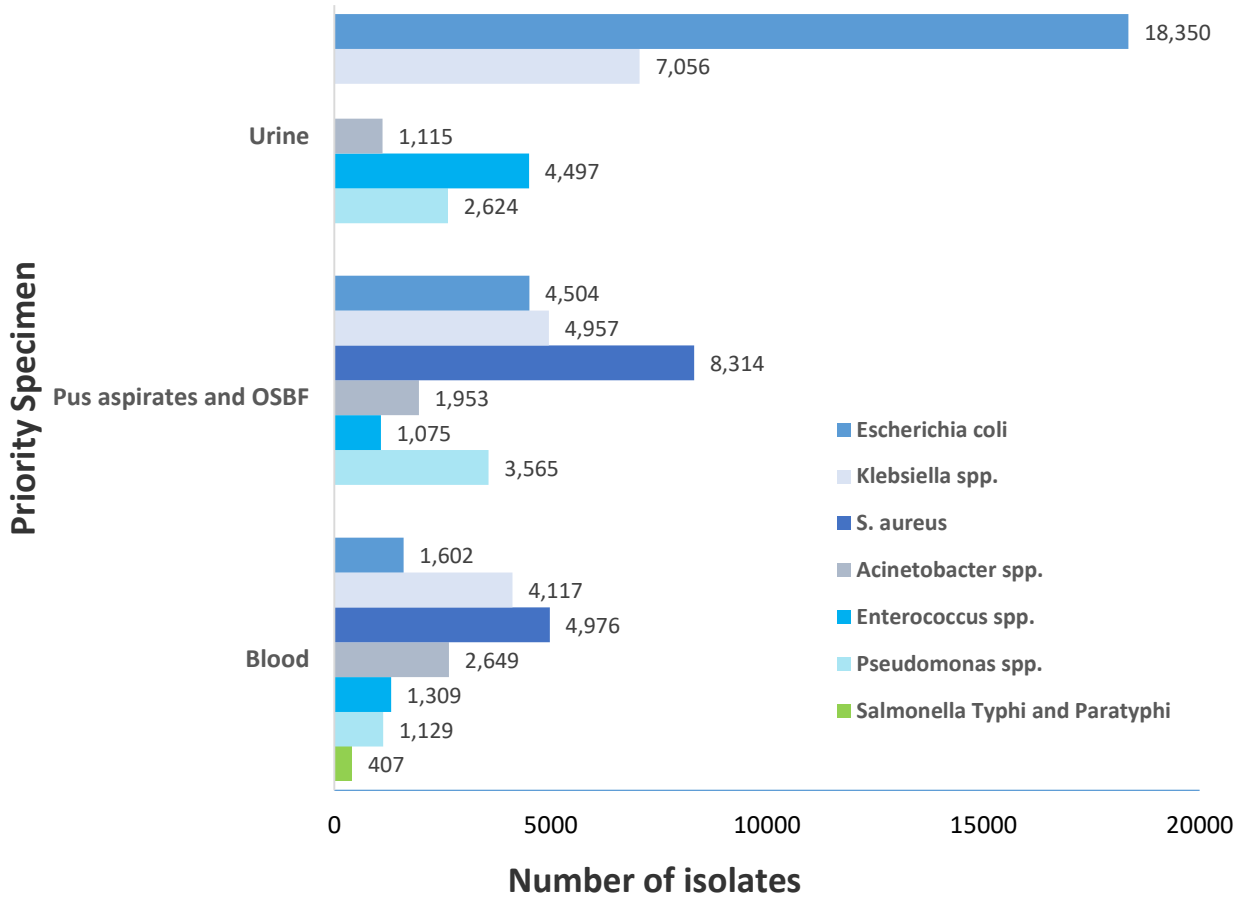

Fig. 5 Specimen wise distribution of AMR surveillance priority pathogens

Table 2 Specimen wise isolation of Priority Pathogens

Priority Pathogens	Blood	Urine	Pus aspirates and OSBF
Escherichia coli	1,602 (10%)	18,350 (55%)	4,504 (18%)
***Klebsiella* spp.**	4,117 (25%)	7,056 (21%)	4,957 (20%)
***Salmonella* Typhi and Paratyphi**	407 (3%)		
***Pseudomonas* spp.**	1,129 (7%)	2,624 (8%)	3,565 (15%)
***Acinetobacter* spp.**	2,649 (16%)	1,115 (3%)	1,953 (8%)
S. aureus	4,976 (31%)		8,314 (34%)
***Enterococcus* spp.**	1,309 (8%)	4,497 (13%)	1,075 (4%)
Total	16,189	33,642	24,368

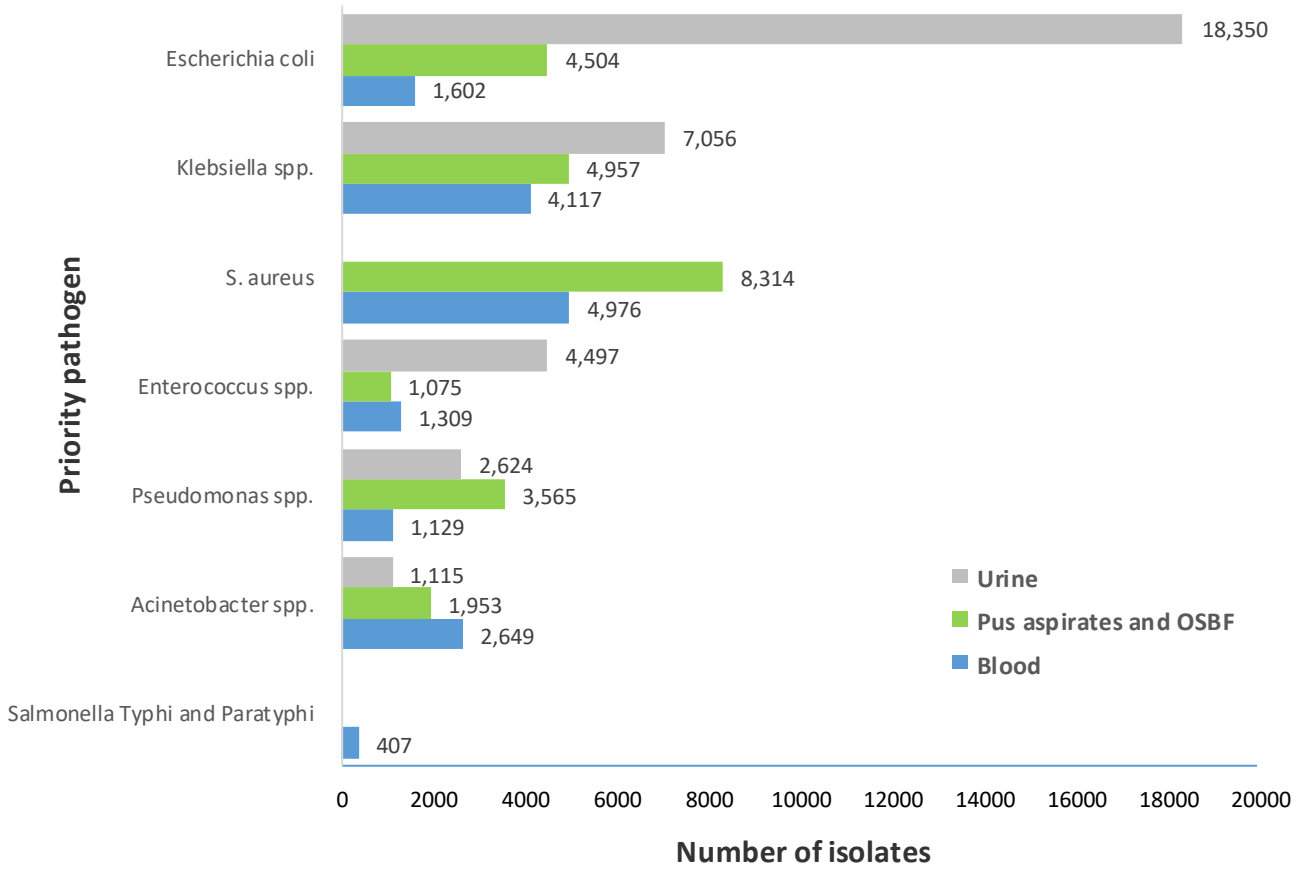

Fig. 6 Specimen wise isolation of the Priority Pathogens

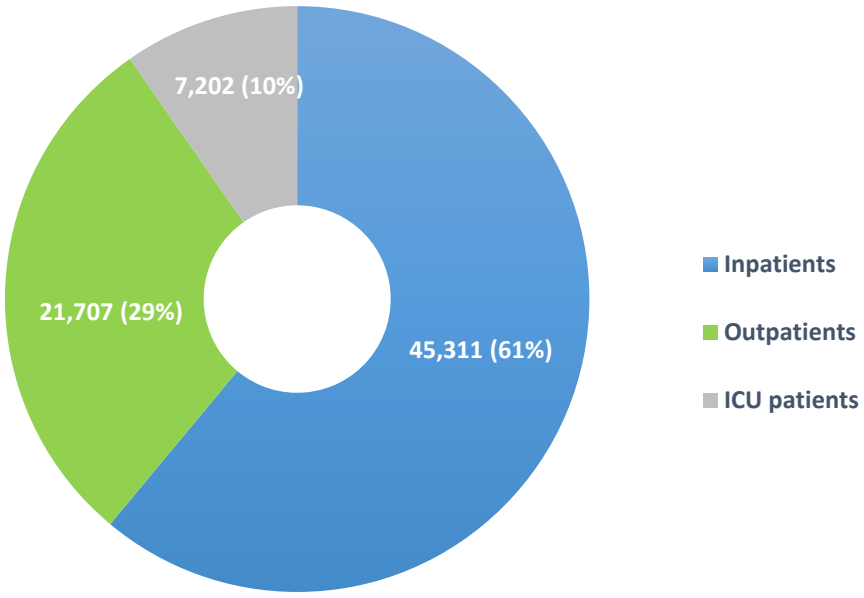

Fig. 7 Location wise distribution of isolates

Of the 74,200 isolates included in the 2019 AMR surveillance data, 10% are from ICU, 29% from in-patient departments (IPD) and 61% from outpatient department (OPD) (Fig. 7). In the ICU patients, *Klebsiella* spp. is the most commonly isolated pathogen (28%) followed by *S.aureus* (18%), *Acinetobacter* spp. (18%), *E.coli* (15%), *Enterococci* spp. (12%) and *Pseudomonas* spp. (9%) (Table 3 and Fig.8). Whereas among the in-patients *E. coli* (30%), is the commonest pathogen isolated followed by *Klebsiella* spp. (22%), *S.aureus* (20%), *Pseudomonas* spp. (10%), *Enterococci* spp. (9%) and *Acinetobacter* spp. (8%) (Table 3 and Fig. 8a).

Table 3 Location wise distribution of priority pathogens

Priority pathogens	ICU	IPD	OPD
Staphylococcus aureus	1,290 (18%)	9,079 (20%)	2,964 (14%)
***Enterococci* spp.**	890 (12%)	4,228 (9%)	1,764 (8%)
Escherichia coli	1,083 (15%)	13,797 (30%)	9,668 (45%)
***Klebsiella* spp.**	2,002 (28%)	9,948 (22%)	4,090 (19%)
***Pseudomonas* spp.**	633 (9%)	4,485 (10%)	2,202 (10%)
***Acinetobacter* spp.**	1,288 (18%)	3,530 (8%)	869 (4%)
***Salmonella* Typhi and Paratyphi A and B**	16 (0.2%)	244 (0.5%)	150 (0.7%)
Total	7,202	45,311	21,707

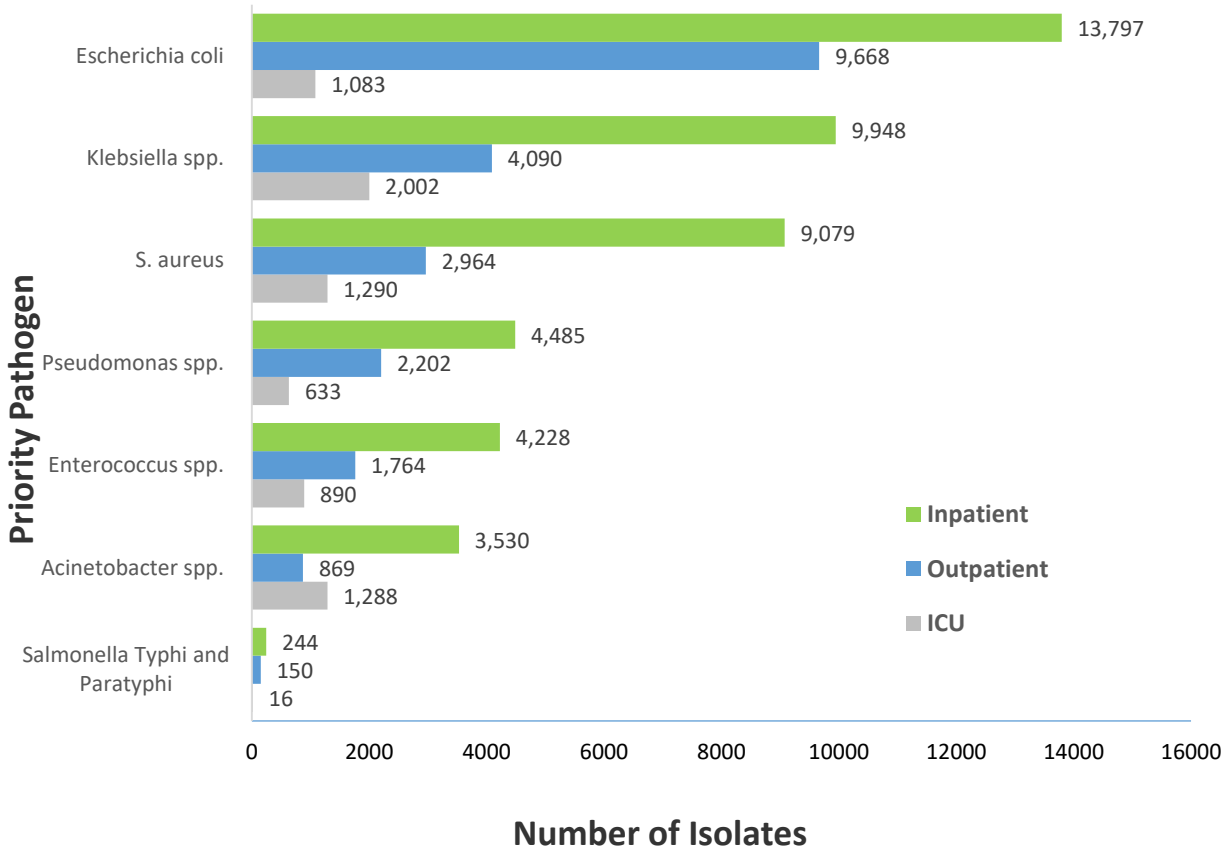

Fig. 8 Distribution of different priority pathogens by location type

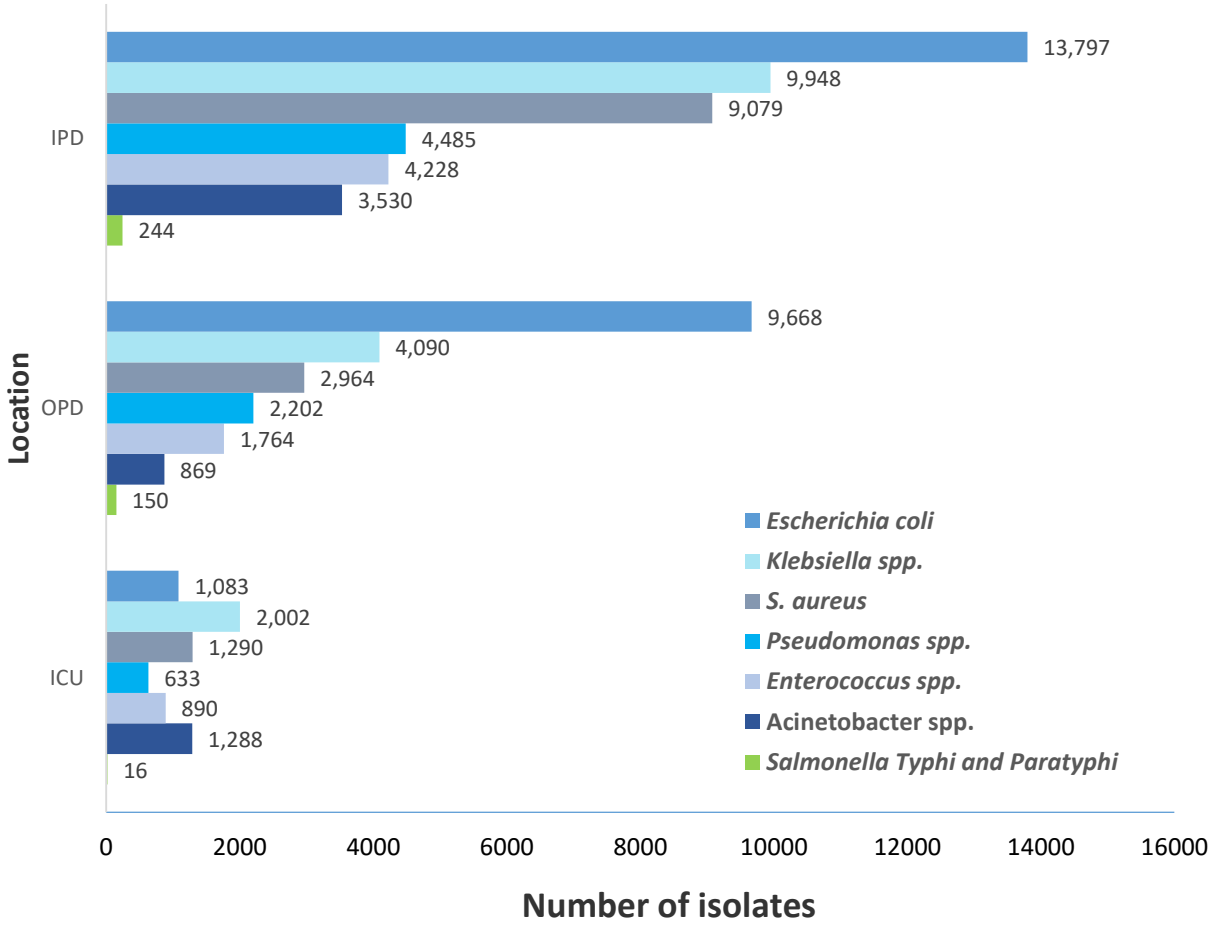

Fig. 8a Location wise distribution of different priority pathogens

VI. AMR profile of priority pathogens

(For select antibiotics as per NCDC AMR Surveillance SOP)

A. Gram Positive Cocci

AMR Surveillance under NARS-Net includes 2 most commonly isolated Gram-positive bacterial pathogens in bacteriology laboratories in India viz.: *Staphylococcus aureus* and *Enterococcus* species. The AST data of 21,090 (27%) Gram-positive cocci (*S. aureus* and *Enterococcus*) have been submitted to NCDC, of which 20,171 isolates are from unique patients. The susceptibility of vancomycin against *S. aureus* is to be tested using broth microdilution test as recommended by CLSI guidelines. However, none of the sites during 2019 reported MIC results for vancomycin against *S. aureus*. In February 2020, some sites have been trained on AST testing for vancomycin using BMD technique and training of remaining sites is under process.

1. *Staphylococcus aureus*

This year the network sites submitted 13,905 *S. aureus* isolate data to the NARS-Net at NCDC of which 13,290 isolates are from unique patients. (Fig.2) AST data analysis of 13,290 *S. aureus* isolates shows that overall resistance to cefoxitin (surrogate marker for *mec*A-mediated oxacillin resistance) is 59%. Of the *S. aureus* isolated from blood, 66% are MRSA.

Ciprofloxacin resistance is observed in 73% of *S. aureus* isolates from aspirated pus and OSBF and in 56% of *S. aureus* isolates from blood (Table 4). Resistance to gentamicin is observed in 23% of *S. aureus* isolates and Linezolid resistance is observed in 1% of *S. aureus* isolates. The data of vancomycin AST for *Staph aureus* is not included as the AST results by BMD were not available for the data-reporting period.

Table 4 Resistance profile of *Staphylococcus aureus*

Antibiotic tested	Blood + PA + OSBF (N=13,290)			Blood (N=4,976)			PA+OSBF (N=8,314)		
	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R
Cefoxitin	11,855	6,994	59	4,499	2,965	66	7,356	4,031	55
Gentamicin	11,342	2,654	23	4,390	1,163	27	6,952	1,495	22
Ciprofloxacin	10,638	7,042	66	4,162	2,322	56	6,476	4,715	73
TMP/SMX	9,983	3,813	38	3,832	1,747	46	6,151	2,054	33
Clindamycin	12,068	3,017	25	4,434	1,477	33	7,634	1,542	20
Erythromycin	12,090	7,290	60	4,644	3,153	68	7,446	4,133	56
Linezolid	12,314	111	0.9	4,648	42	0.9	7,666	69	0.9
Doxycycline	8,480	840	10	3,422	366	11	5,058	470	9

Abbreviations: OSBF, Other sterile body fluids; PA, Pus aspirates

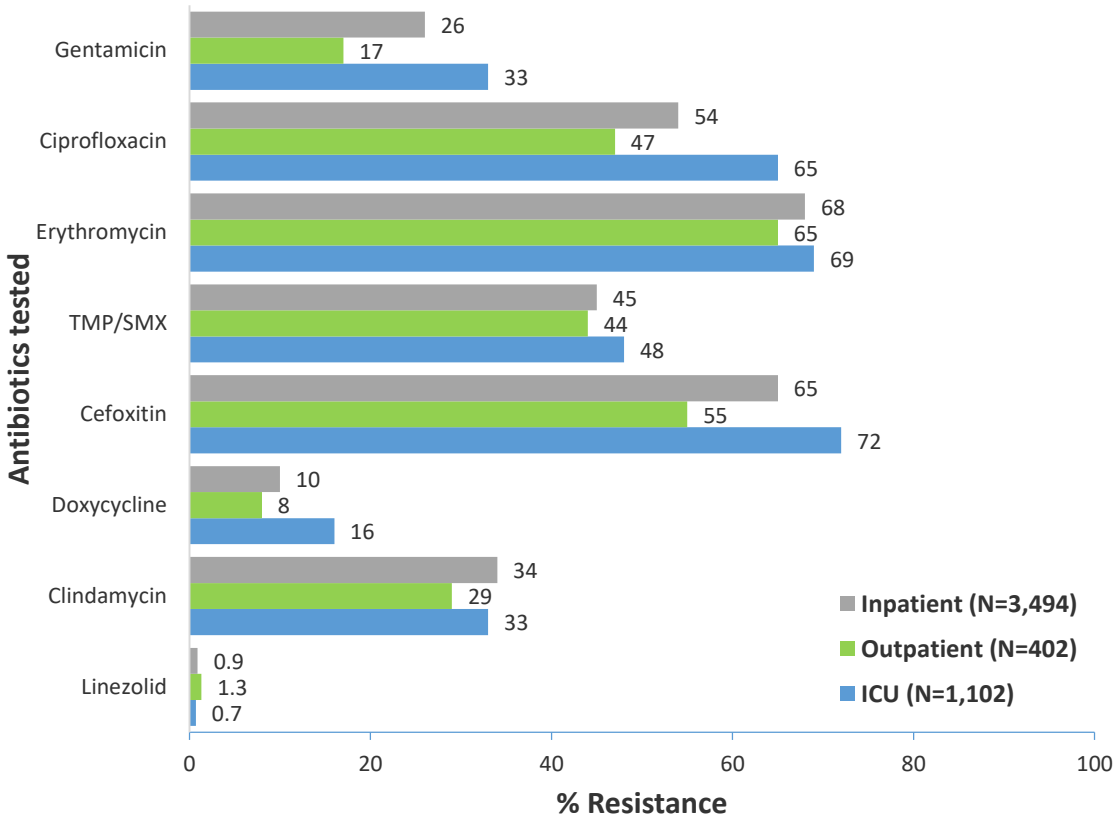

Fig. 9 Resistance profile of Staphylococcus aureus isolated from blood specimens from different location types in healthcare facilities

As compared to non-ICU settings, higher resistance rates are observed in *S. aureus* isolates from ICUs for all the antibiotics (Fig. 8). Of the *S. aureus* isolates from blood specimens of ICU patients, 72% are resistant to cefoxitin (MRSA), 70% to erythromycin and 33.5% to clindamycin. (Fig. 9)

Compared to other antibiotics, lower rates of resistance to aminoglycoside and lincosamide class of antibiotics is observed in *S. aureus* isolates from pus aspirates and OSBF (Fig. 10). Resistance to ciprofloxacin is observed to be higher in isolates of *S. aureus* from pus aspirates and OSBF (inpatients, 73%; outpatients, 72%) than isolates from blood specimens (inpatients, 54%; outpatients, 47%). (Fig. 9 & 10)

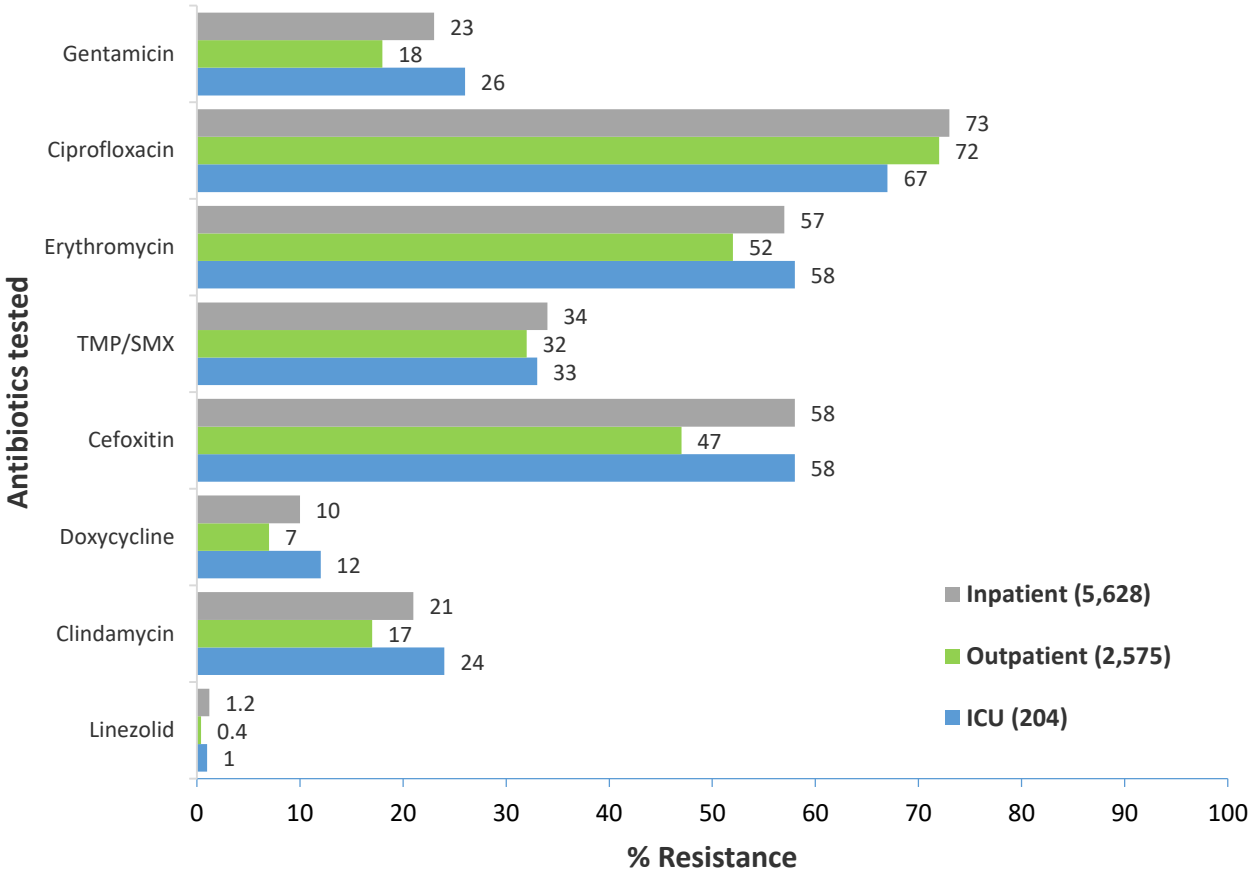

Fig. 10 Resistance profile of Staphylococcus aureus isolated from PA and OSBF specimens from different location types in healthcare facilities

2. *Enterococcus* species

Of the 6,881 isolates of *Enterococcus* spp., 48% are resistant to high-level gentamicin. Sixty one percent of isolates of *Enterococcus* spp. isolated from urine are resistant to tetracycline. Thirteen percent *Enterococcus* isolates are resistant to vancomycin and 5% of the isolates are resistant to linezolid. Notably, there is an alarming level of resistance to linezolid among *Enterococcus* spp. (5%) isolated from urine specimens. (Table 5)

Table 5: Resistance profile of *Enterococcus* species

Antibiotic tested	Blood+Urine+PA+OSBF (N=6,881)			PA+OSBF (N=1,075)			Blood (N=1,309)			Urine (N=4,497)		
	Number Tested	Number Resistant	%R	Number Tested	Number Resistant	% R	Number Tested	Number Resistant	%R	Number Tested	Number Resistant	%R
Ampicillin	5,572	3,416	61	769	410	53	970	674	70	3,833	2,327	61
Gentamicin-High	5,028	2,408	48	796	295	37	968	497	51	3,264	1,609	49
Ciprofloxacin	5,349	4,140	77							3,684	2,947	80
Erythromycin	3,331	2,668	80	887	674	76	1,170	929	79			
Linezolid	6,345	311	5	986	35	4	1,211	55	5	4,148	220	5
Vancomycin	5,332	688	13	812	67	8	1,000	164	16	3,520	458	13
Doxycycline	2,295	991	43	504	193	38	699	275	39			
Tetracycline	3,064	1,844	60							2,504	1,530	61

Abbreviations: OSBF, Other sterile body fluids; PA, Pus aspirates

As observed in *S. aureus* isolates, similar trend of higher resistance is observed in ICU isolates of *Enterococcus* spp. from all the specimens for most of the antibiotics (Fig. 11). Observation of 27% VRE and 9% linezolid resistant *Enterococcus* spp. in urine specimens from ICU patients is worrisome (Fig. 12). *Enterococcus* spp. from blood, PA and OSBF also showed higher rates of resistance i.e. 21% VRE and 5% linezolid resistance (Fig. 11).

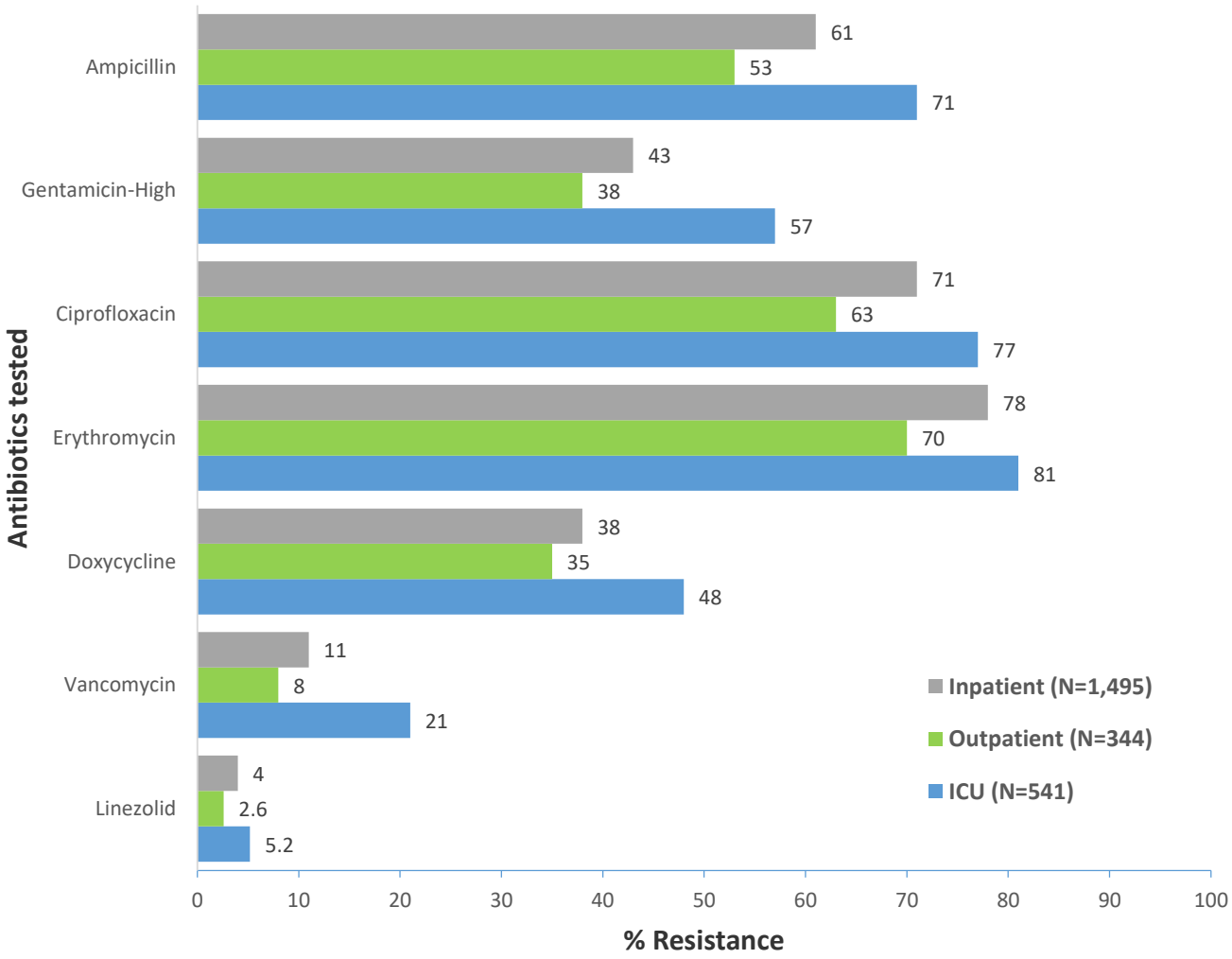

Fig. 11 Resistance profile of Enterococcus spp. isolated from blood, PA and OSBF from different location types in healthcare facilities

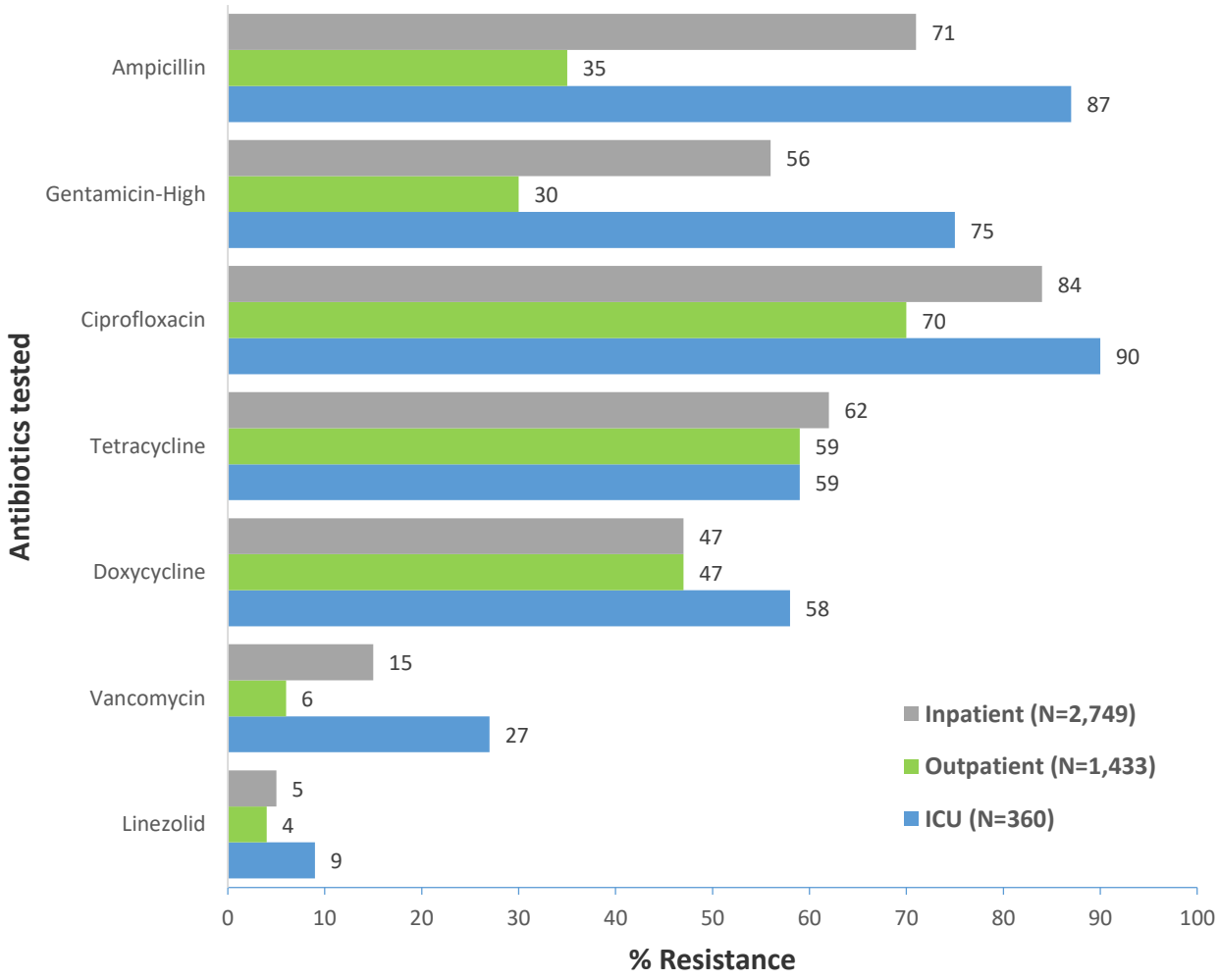

Fig. 12 Resistance profile of Enterococcus spp. isolated from urine specimens from different location types in healthcare facilities

B. Gram Negative Bacilli

In the NARS-Net, five most commonly isolated gram-negative bacilli in the Indian healthcare settings are included under AMR surveillance. This constitutes *E. coli*, *Klebsiella* species, *Pseudomonas* species, *Acinetobacter* species and *Salmonella enterica* serovar Typhi and Paratyphi. AST data of 57,770 isolates of gram-negative bacilli have been reported from 54,029 unique patients during period of January 2019 to December 2019 from 21 sentinel sites. This accounts for 73% of total isolates included in this report.

1. Enterobacteriaceae

E. coli, *Klebsiella* spp., and *Salmonella enterica* serotype Typhi and Paratyphi account for 76% (43,878) of Gram negative bacilli included in this annual AMR Surveillance report. Of these 43,878 Enterobacteriaceae isolates received from 21 sentinel sites, 40,994 are from unique patients. All the isolates have been phenotypically characterized by the sites using standard bacteriological identification techniques and AST performed using Kirby Bauer disc diffusion method. Of the 21 sites, two sites have also provided AST data from automated bacterial identification and AST testing system.

a) *Escherichia coli*

E. coli isolated from blood showed 82% resistance to cefotaxime and 63% to cefepime whereas urine isolates show higher level of resistance to cefepime (66%) than to cefotaxime (77%). (Table 6) Resistance to imipenem is found to be 33% in *E. coli* blood isolates which is higher than that observed in urine isolates (32% resistance to imipenem). The colistin susceptibility testing has been done using broth microdilution method as per CLSI document M02 and M100, though for a limited number of isolates. (Table 6)

Table 6: Resistance profile of *E. coli*

Antibiotic tested	Blood + Urine + PA + OSBF (N=24,456)			PA+OSBF (N=4,504)			Blood (N=1,602)			Urine (N=18,350)		
	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R
Ampicillin	14,943	12,971	87	2,563	2,327	91	1,087	934	86	11,293	9,701	86
Cefotaxime	18,183	14,219	78	3,310	2,641	80	1,030	841	82	13,843	10,701	77
Cefepime	16,029	10,531	66	3,132	2,070	66	1,139	715	63	11,758	7,748	66
Ertapenem	6,475	2,545	39	1,289	505	39	485	223	46	4,701	1,805	38
Imipenem	19,124	6,120	32	3,840	1,248	33	1,420	469	33	13,864	4,395	32
Ciprofloxacin	21,162	16,718	79	3,736	2,963	79	1,385	994	72	16,041	12,720	79
TMP/SMX	18,067	11,563	64	2,613	1,714	66	1,025	592	58	14,429	9,249	64
Colistin	3,205	16	0.5	540	7	1.3	346	1	0.3	2,319	7	0.3
Nitrofurantoin	16,741	2,026	12							16,741	2,042	12

Abbreviations: OSBF, Other sterile body fluids; PA, Pus aspirates; Sensitivity of *E. coli* against colistin is tested using broth microdilution test method

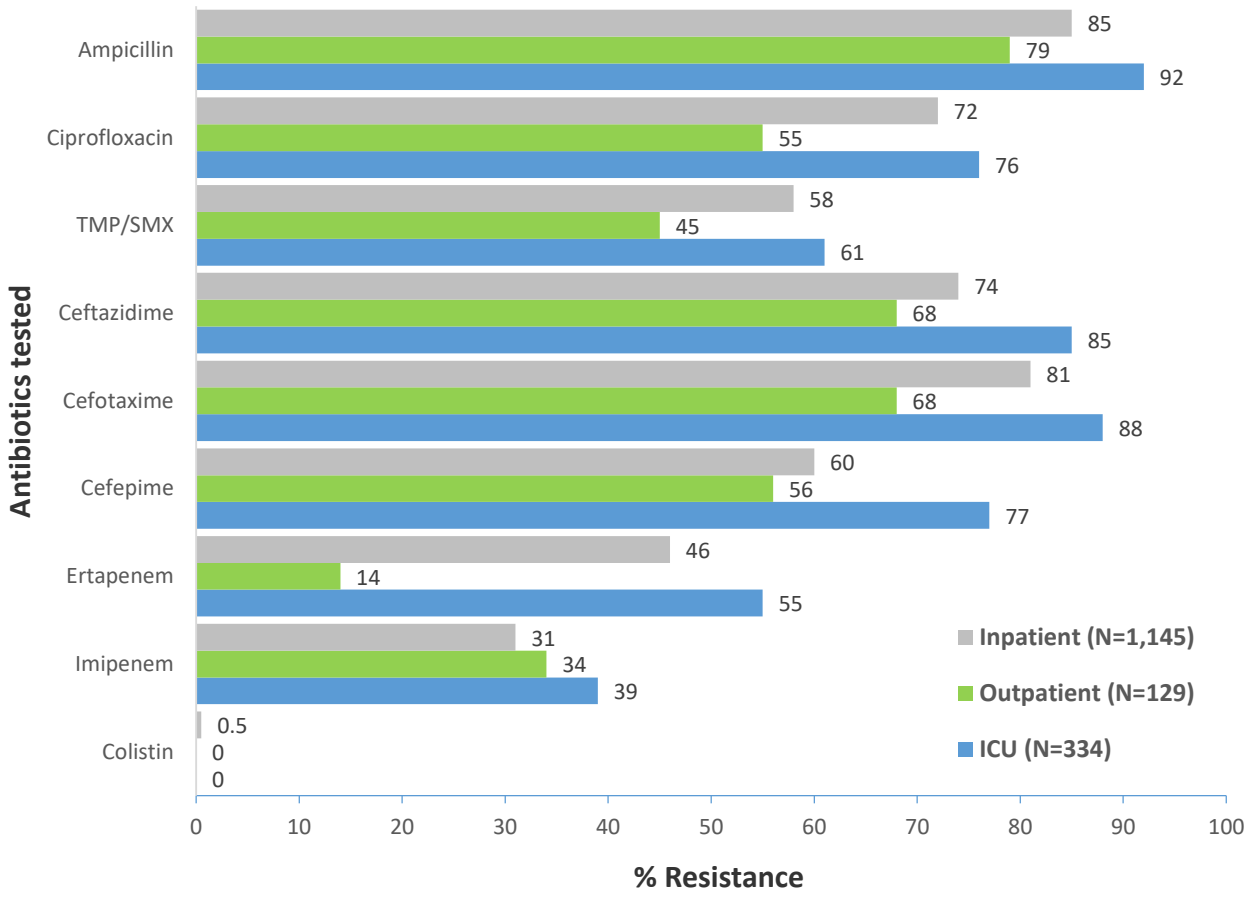

Fig. 13 Resistance profile of *E. coli* isolated from blood specimens from different location types in healthcare facilities

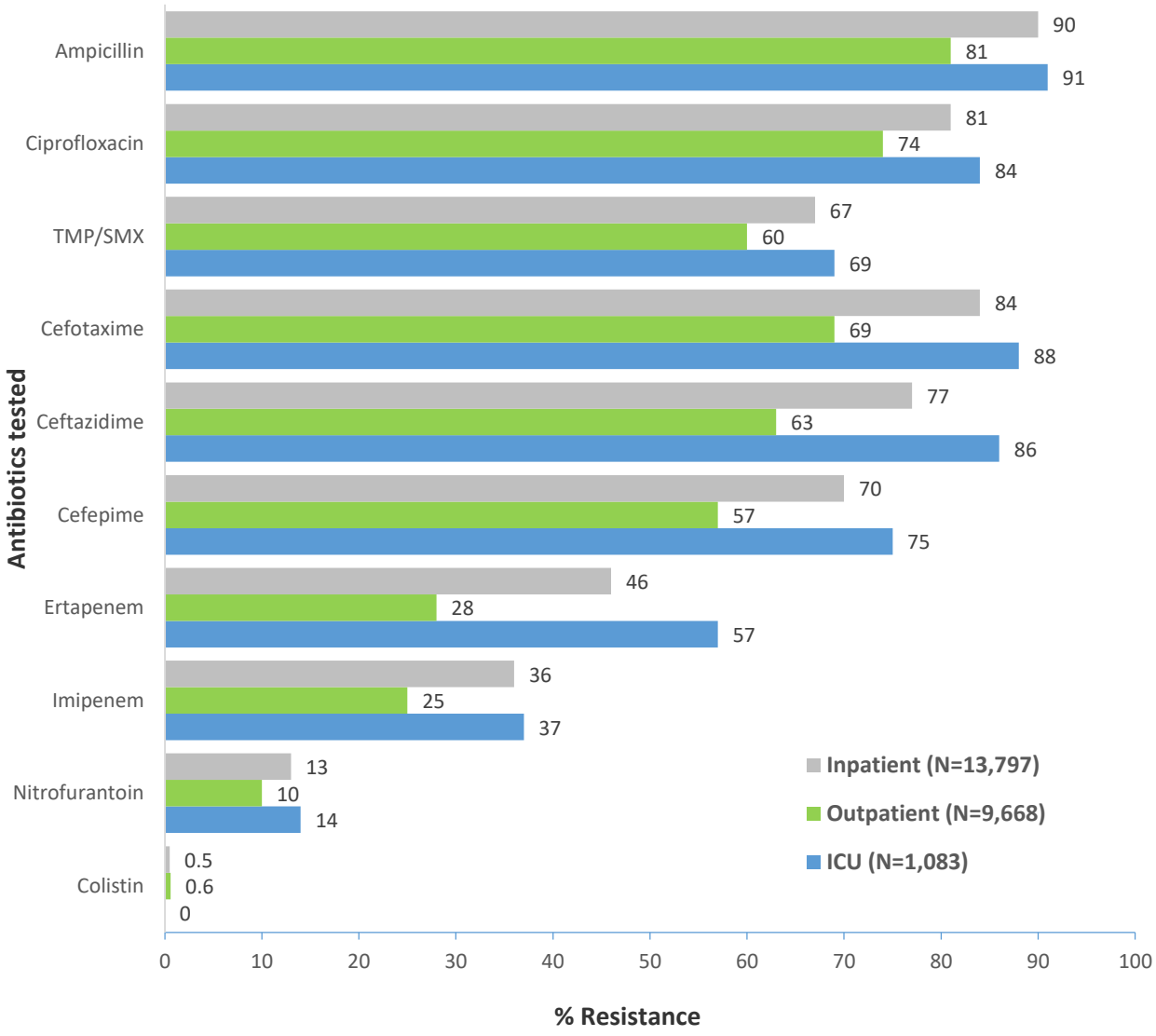

Fig. 14 Resistance profile of *E. coli* isolated from blood, urine, PA and OSBF from different location types in healthcare facilities

b) *Klebsiella* species

High level of resistance is seen in *Klebsiella* spp. isolated from blood: 86% resistance is observed to cefotaxime, 74% to cefepime and alarmingly high resistance to imipenem (49%). (Table 7) Broth microdilution susceptibility testing to colistin has been reported for only 2,078 *Klebsiella* isolates and the data shows high level resistance to colistin in blood isolates (3.5%) and in urine isolates (3%).

Table 7: Resistance profile of *Klebsiella* species

Antibiotic tested	Blood+Urine+PA+OSBF (N=16,130)			PA+OSBF (N=4,957)			Blood (N=4,117)			Urine (N=7,056)		
	Number tested	Number Resistant	% R	Number tested	Number Resistant	% R	Number tested	Number Resistant	% R	Number tested	Number Resistant	% R
Piperacillin/ Tazobactam	12,013	6,151	51	4,199	2,330	56	3,494	2,236	64	4,320	1,607	37
Cefotaxime	12,178	9,560	79	3,859	3,076	80	2,810	2,428	86	5,509	4,032	73
Cefepime	10,973	7,495	68	3,703	2,588	70	2,785	2,072	74	4,485	2,852	64
Ertapenem	3,529	1,881	53	1,004	494	49	835	572	69	1,690	803	48
Imipenem	13,854	5,930	43	4,386	2,057	47	3,702	1,829	49	5,766	2,035	35
Meropenem	2,746	1,519	55	877	526	60	1,172	739	63	697	257	37
Amikacin	12,336	5,761	47	3,973	2,066	52	3,489	1,936	56	4,874	1,774	36
Ciprofloxacin	13,866	9,886	71	4,164	3,094	74	3,539	2,608	74	6,163	4,179	68
TMP/SMX	11,614	7,224	62	3,095	2,080	67	2,930	1,849	63	5,589	3,303	59
Colistin	2,119	59	3	438	11	3	736	26	3.5	945	28	3

Abbreviations: OSBF, Other sterile body fluids; PA, Pus aspirates; Sensitivity of *Klebsiella* spp. against colistin is tested using broth microdilution test method.

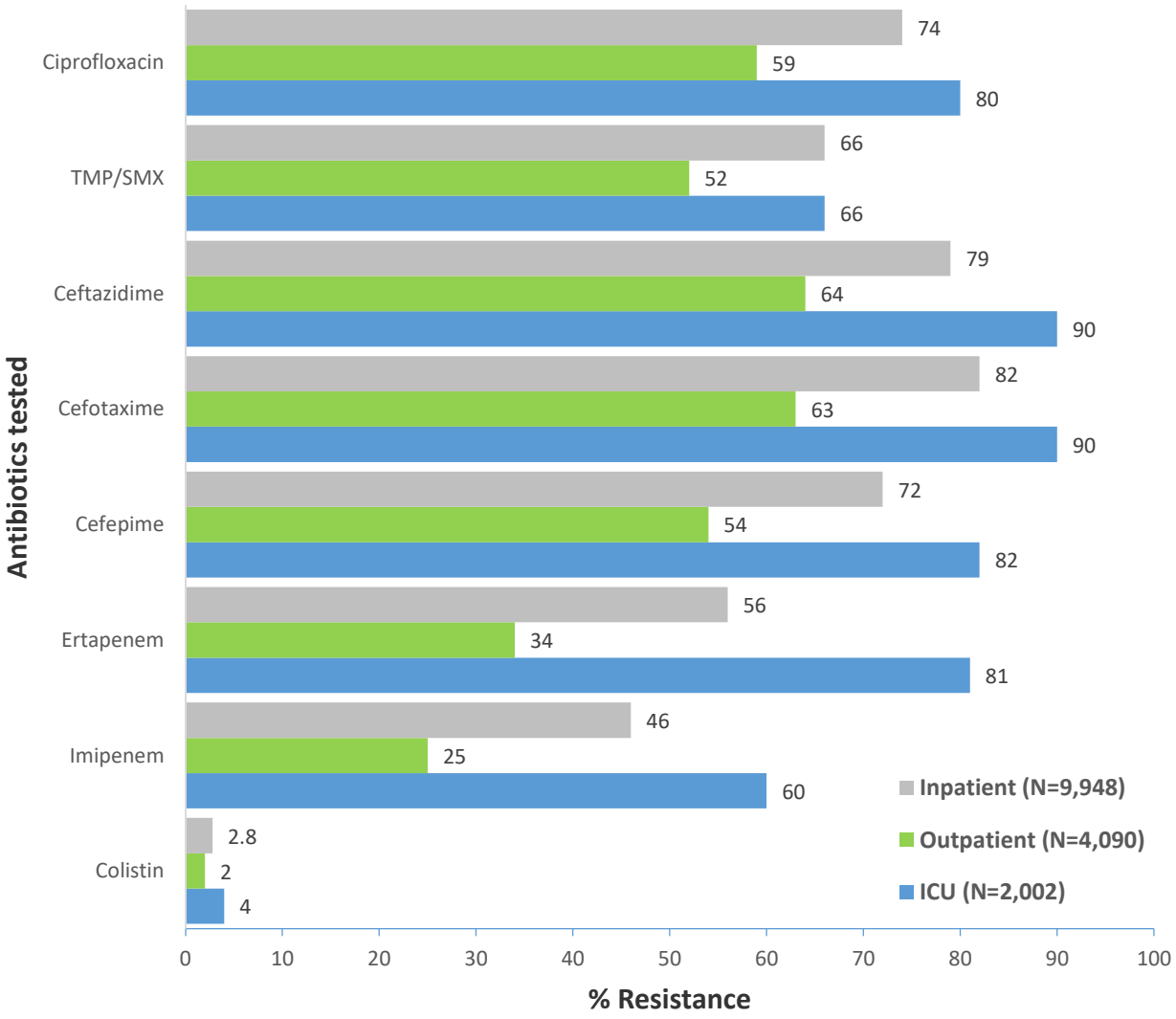

Fig. 15 Resistance profile of *Klebsiella* spp. isolated from blood, urine, PA and OSBF from different location types in healthcare facilities

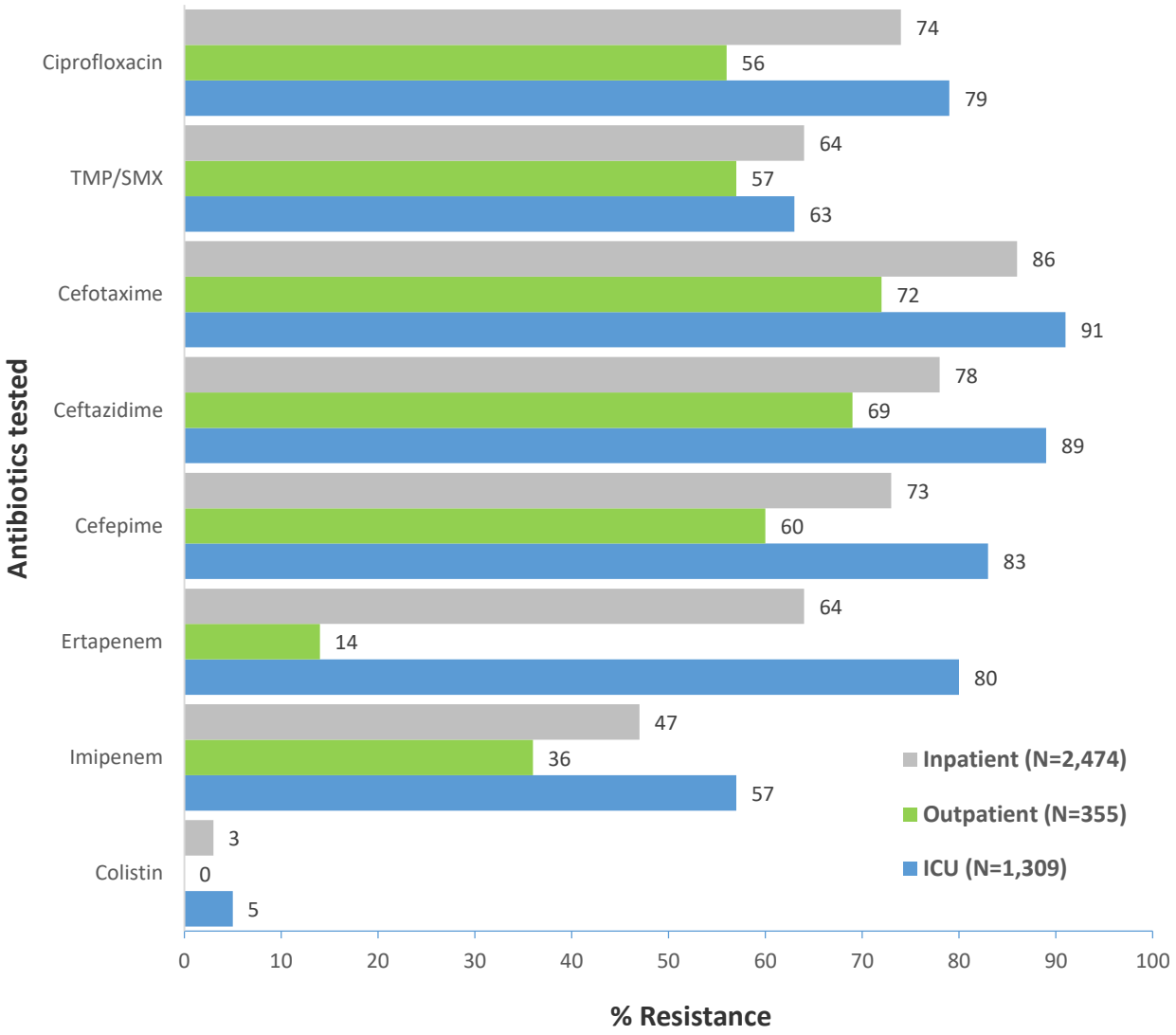

Fig. 16 Resistance profile of *Klebsiella* spp. isolated from blood specimens from different location types in healthcare facilities

c) Comparison of susceptibility of *E. coli* and *Klebsiella* species

Among the gram-negative lactose fermenting isolates from blood, *Klebsiella* spp. shows higher resistance to all the antibiotics than *E. coli* except for ciprofloxacin (Fig. 18). While *E. coli* from urine has higher resistance to most of the antibiotics as compared to *Klebsiella* spp. except for ampicillin, carbapenems and colistin (Fig. 17). *Klebsiella* spp. from both urine and blood specimens are observed to have higher resistance to carbapenems than *E. coli* isolates. *E. coli* isolates from urine show higher level of resistance to 2nd and 3rd generation cephalosporins than *Klebsiella* spp. isolates from urine (Fig. 17).

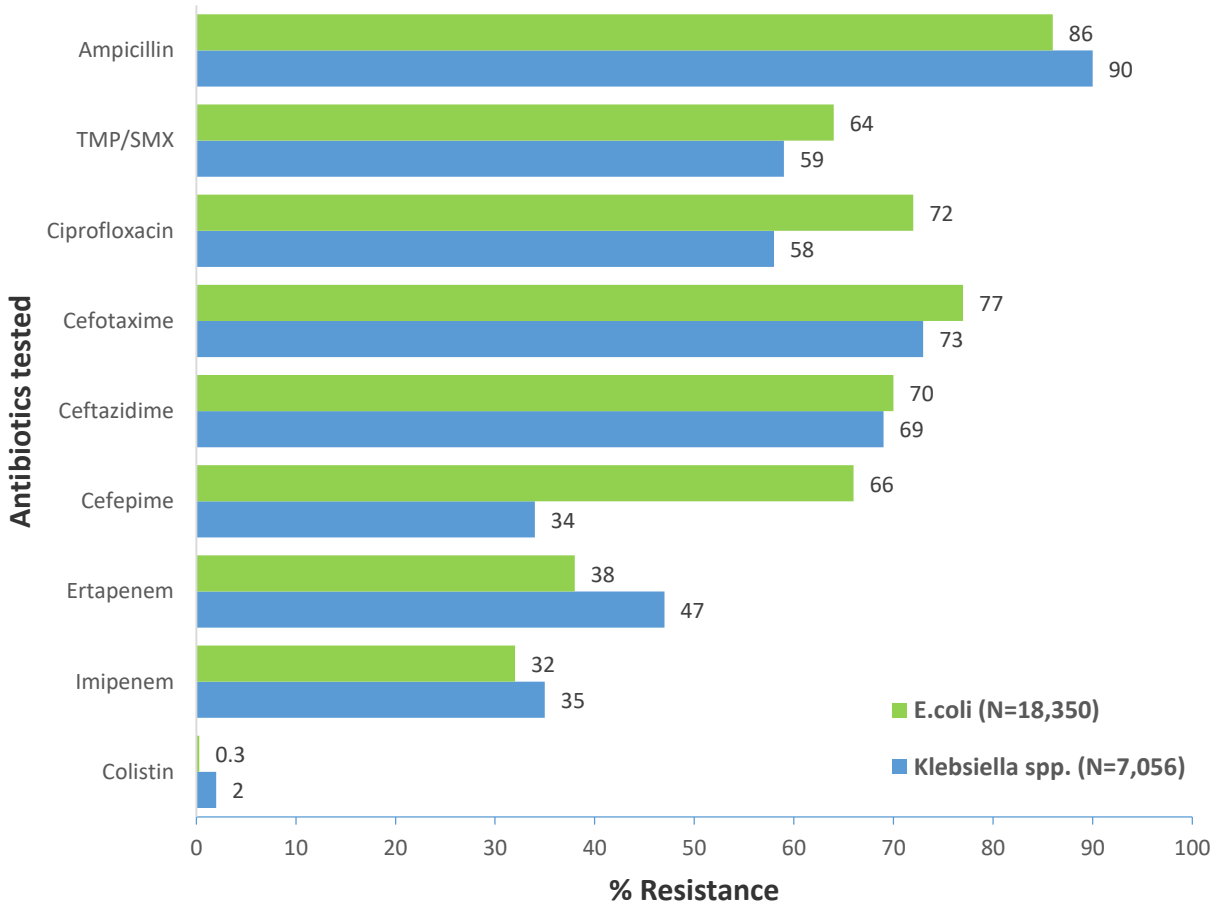

Fig. 17 Resistance profile of *E. coli* and *Klebsiella* spp. isolated from urine specimens

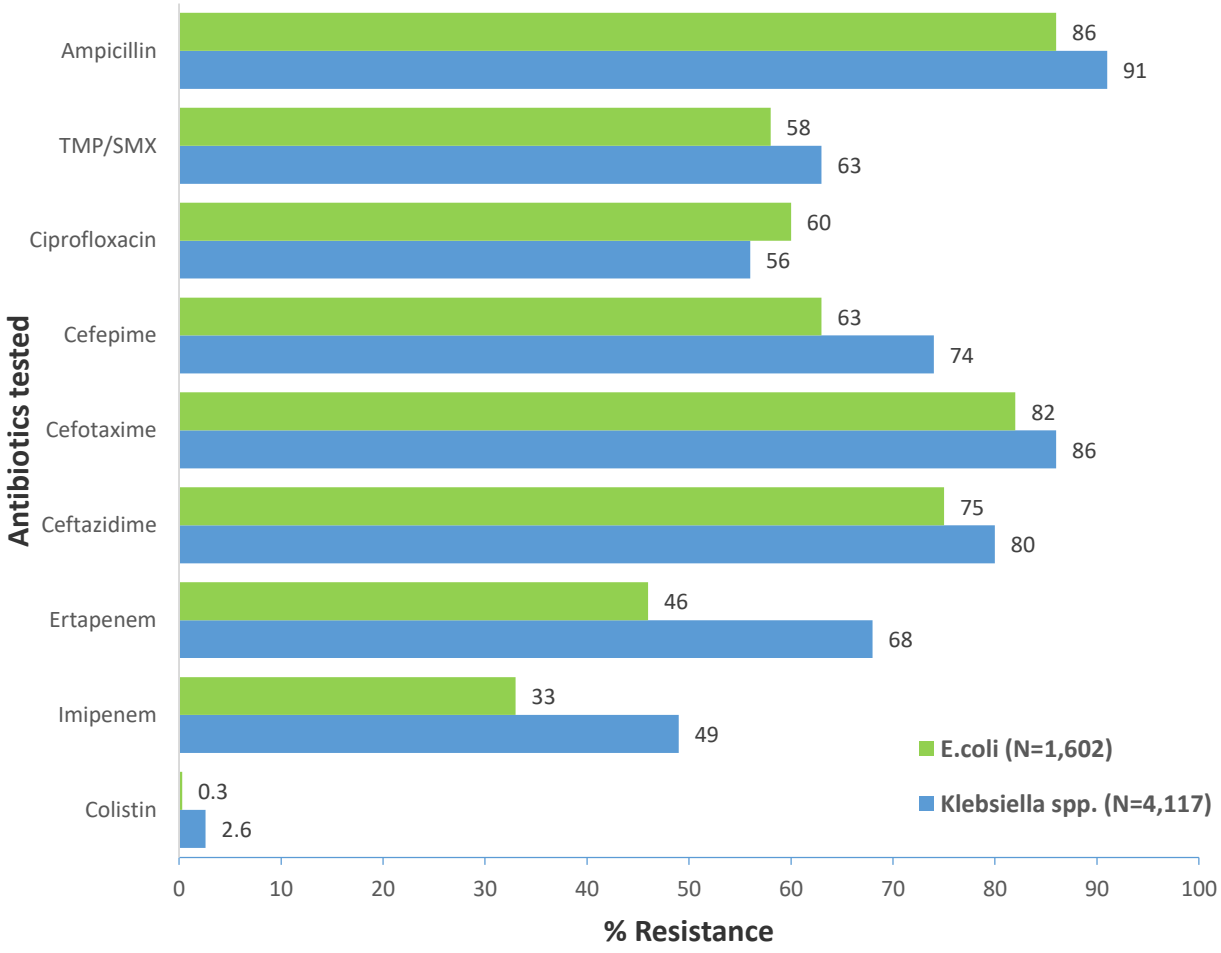

Fig. 18 Resistance profile of *E. coli* and *Klebsiella* spp. obtained from blood specimens

The most common pathogen in ICU setting is *Klebsiella* spp. whereas *E. coli* is most commonly isolated in inpatients (Table 3). Except for carbapenems, more than 50% resistance to all the tested antibiotics is observed in *E. coli* isolated from blood of patients from ICU and inpatients (Fig. 13). Higher levels of resistance to all the tested antibiotics is observed in *Klebsiella* spp. isolated from blood of ICU patients (Fig. 16). *Klebsiella* spp. isolated from blood of ICU patients show 5% resistance to colistin which is of major concern as colistin is the last resort drug for treatment of infections caused by gram negative bacilli (Fig. 16).

d) *Salmonella enterica* serotypes Typhi and Paratyphi

Salmonella enterica serotype Typhi isolated from blood show 36% resistance to ciprofloxacin and 0.7% resistance to ceftriaxone. Resistance to azithromycin in *Salmonella* Typhi isolates is 3.3%, which is lower than that from previous year (8%). (Table 8) Only one isolate of *Salmonella* Typhi has been reported from stool specimen hence is not included in the analysis.

Table 8 Resistance profile of *Salmonella enterica* serotypes Typhi and Paratyphi isolated from blood specimens

Antibiotic tested	S.Typhi (N=389)			S. Paratyphi (N=18)	
	Number tested	Number Resistant	%R	Number tested	Number Resistant
Ampicillin	320	60	19	14	1
Ciprofloxacin	364	131	36	17	3
Trimethoprim/Sulfamethoxazole	340	25	7	11	0
Chloramphenicol	253	13	5	8	0
Ceftriaxone	301	2	0.7	12	2
Cefepime	238	5	2	2	0
Imipenem	282	0	0	6	0
Azithromycin #	305	10	3		

AST for Azithromycin was performed only on isolates of S. Typhi

2. Non-Fermenting Gram-Negative Bacilli

Among non-fermenting gram-negative bacilli (NFGNB), the two most prevalent bacteria are included in the priority pathogen list of NARS-Net i.e. *Pseudomonas* spp. and *Acinetobacter* spp. These account for 24% (13,892) of Gram negative bacilli included in this annual AMR Surveillance report. The data of 13,892 isolates of NFGNB is from 13,035 unique patients. *Pseudomonas* spp. is most frequently isolated from PA and OSBF (49%) whereas *Acinetobacter* spp. is isolated mainly from blood specimens (46%).

a) *Pseudomonas* species

Pseudomonas spp. show least resistance to piperacillin-tazobactam (31%) followed by imipenem (38%), aminoglycosides (amikacin: 45%; gentamicin: 49%), ceftazidime (53%) and ciprofloxacin (54%). (Tables 9) Not surprisingly, the isolates from ICU show higher resistance as compared to isolates from non-ICU settings (Fig. 19). Isolates of *Pseudomonas* spp. from

PA and OSBF show higher resistance to colistin (8%) than isolates from blood (4%) and urine (3%) (Table 9). *Pseudomonas* spp. isolated from ICU patients show high levels of resistance to carbapenems (imipenem: 50% and meropenem: 46%). Notably, *Pseudomonas* spp. isolated from both ICU and inpatients show >40% resistance to all the tested antibiotics except for piperacillin-tazobactam and Colistin. (Fig. 19)

Table 9: Resistance profile observed in *Pseudomonas* species

Antibiotic tested	Blood+Urine+PA+OSBF (N=7,318)			PA+OSBF (N=3,565)			Blood (N=1,129)			Urine (N=2,624)		
	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R
Piperacillin/ Tazobactam	6,515	2,007	31	3,098	991	32	1,000	228	23	2,417	766	32
Ceftazidime	6,306	3,336	53	3,137	1,703	54	894	426	48	2,275	1,226	54
Cefepime	3,387	1,822	54	1,835	1,017	55	565	234	41	987	576	58
Imipenem	6,551	2,502	38	3,199	1,219	38	1,033	312	30	2,319	983	42
Amikacin	6,434	2,870	45	3,052	1,398	46	997	340	34	2,385	1,126	47
Gentamicin	4,952	2,422	49	2,388	1,218	51	820	307	37	1,744	909	52
Ciprofloxacin	6,537	3,517	54	3,140	1,529	49	1,006	321	32	2,391	1,427	60
Colistin	982	51	5	285	24	8	218	8	3.7	479	15	3.1

Abbreviations: OSBF, Other sterile body fluids; PA, Pus aspirates; Sensitivity of *Pseudomonas* spp. against colistin is tested using broth microdilution test method.

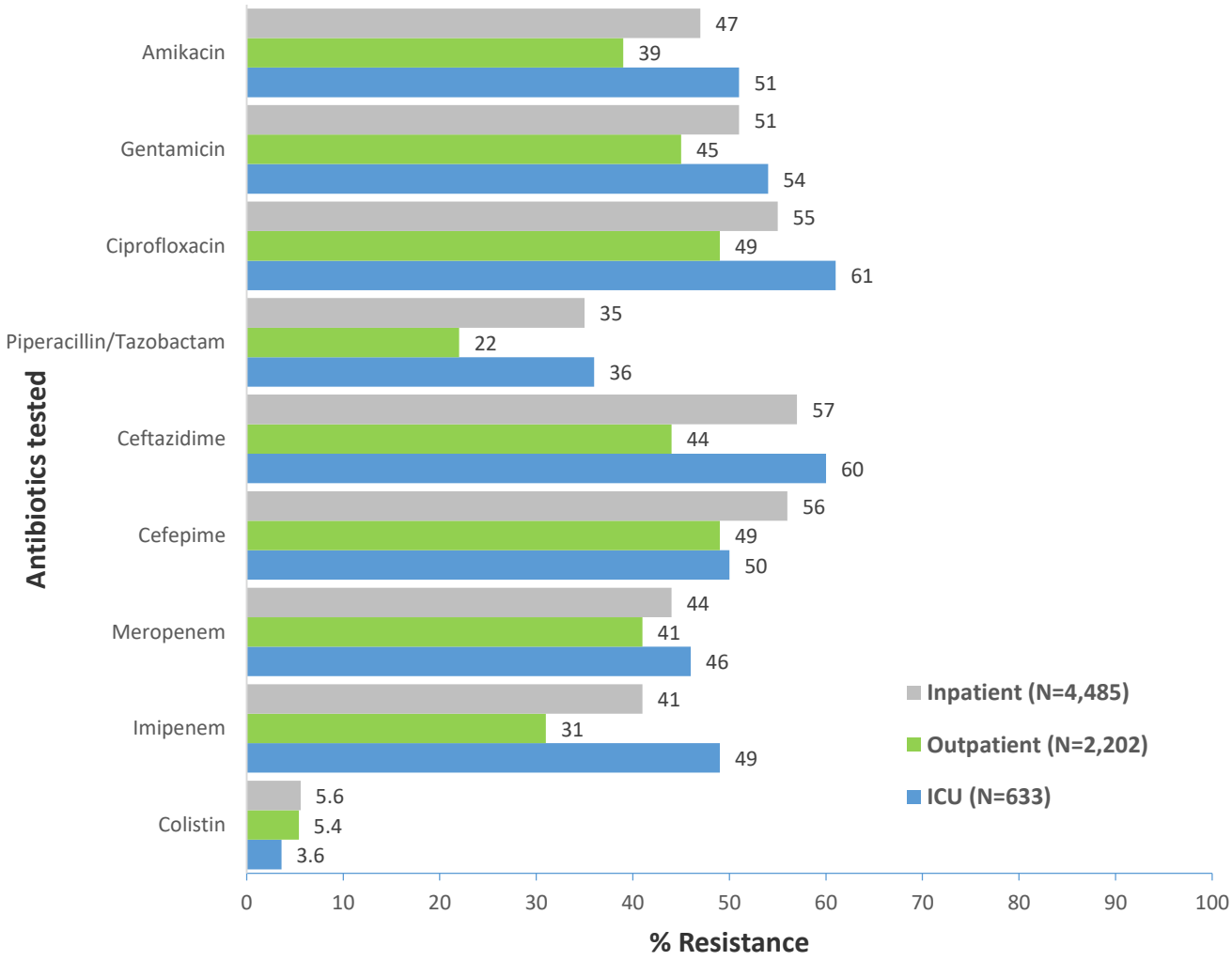

Fig. 19 Resistance profile of *Pseudomonas* species isolated from blood, urine, PA and OSBF from different location types in healthcare facilities

b) *Acinetobacter* spp.

Acinetobacter species reported under the NARS-Net show markedly high resistance to all the tested antibiotics in isolates from ICU and inpatients than isolates for the outpatients. (Fig. 20)

Acinetobacter spp. show >50% resistance to almost all the antibiotics tested except for minocycline (29%). (Table 10) However, 27% resistance to minocycline in *Acinetobacter* spp. isolates from ICU patients is of concern. (Fig. 20)

Table 10 Resistance profile observed in *Acinetobacter* species

Antibiotic tested	Blood+Urine+PA+OSBF (N=5,717)			PA+OSBF (N=1,953)			Blood (N=2,649)			Urine (N=1,115)		
	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R	Number tested	Number Resistant	%R
Piperacillin/ Tazobactam	4,898	2,958	60	1,692	1,205	71	2,325	1,323	57	881	441	50
Ceftazidime	4,150	3,216	78	1,576	1,295	82	1,873	1,450	77	701	470	67
Cefepime	2,541	1,733	68	1,041	813	78	1,160	733	63	340	195	57
Imipenem	4,868	2,853	59	1,718	1,141	66	2,287	1,310	57	863	409	47
Amikacin	4,862	2,922	60	1,705	1,187	70	2,273	1,337	59	884	405	46
Gentamicin	3,450	1,891	55	1,110	700	63	1,664	864	52	676	329	49
Ciprofloxacin	5,033	3,251	65	1,695	1,251	74	2,343	1,411	60	995	598	60
TMP/SMX	3,377	1,884	56	1,040	669	64	1,593	849	53	744	370	50
Colistin	1,134	62	5.5	296	22	7	610	31	5	228	9	4
Minocycline	1,955	469	24	577	158	27	998	181	18	380	131	34.5

Abbreviations: OSBF, Other sterile body fluids; PA, Pus aspirates; Sensitivity of *Acinetobacter* spp. against colistin is tested using broth microdilution test method.

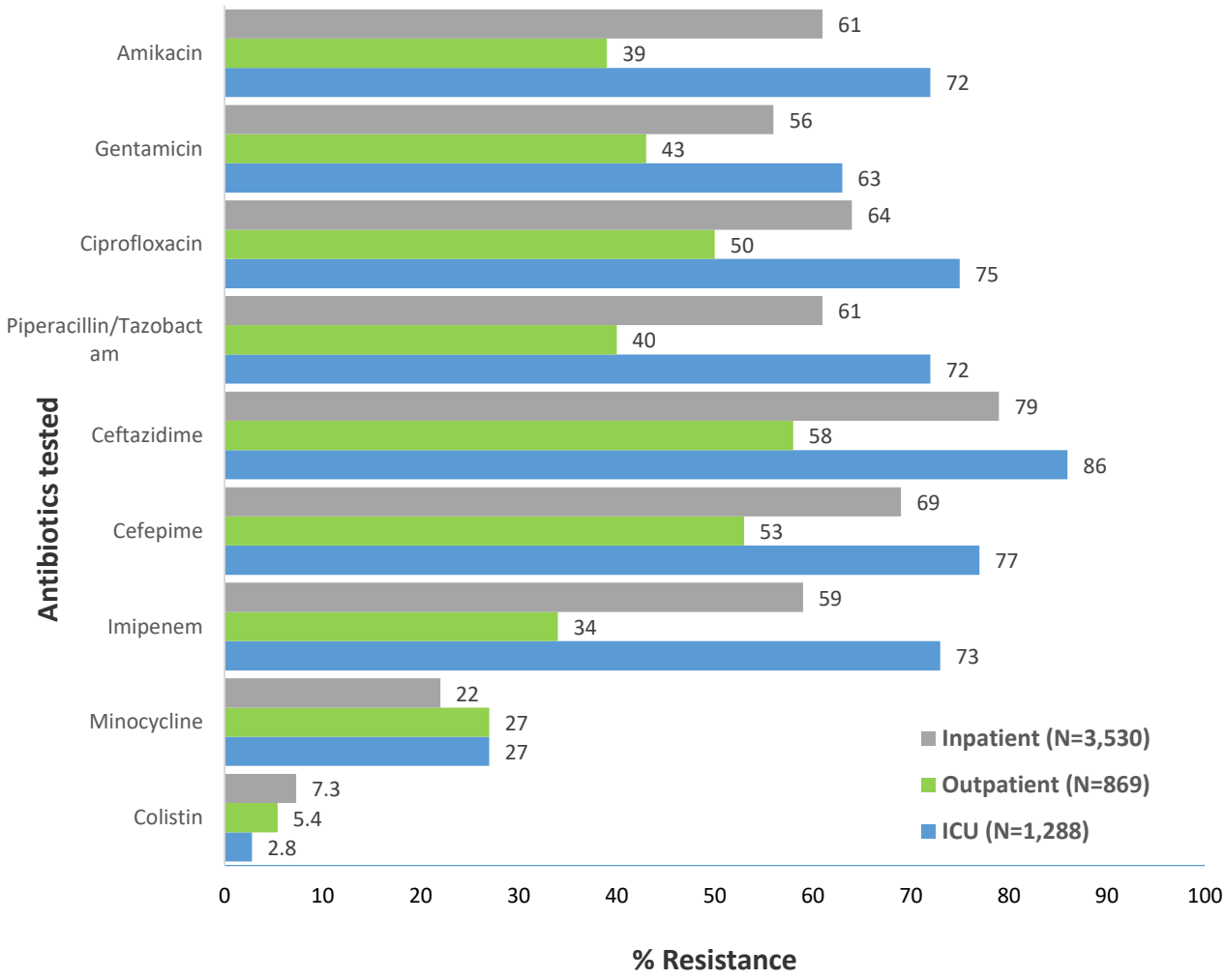

Fig. 20 Resistance profile of *Acinetobacter* spp. isolated from blood, urine, PA and OSBF from different location types in healthcare facilities

VII. Discussion

The NARS-Net is collating National AMR surveillance data and sharing resistance profile of commonly used antibiotics to stakeholders at the National and state level. This data is also submitted at the global level to WHO-GLASS. Various efforts are being made to strengthen quality of lab testing so as to generate good quality data, namely external quality assessment, development of internal quality control and data management SOPs, provision of trainings, regular feedback on data quality etc. However, certain limitations which could affect this data are absence of strict SOP compliance by some sites regarding rigorous quality checks for antibiotic discs, e.g. imipenem discs deteriorate frequently and if IQC is not rigorous, may give rise to falsely high resistance rates. In the year 2020, a capacity-building program has been initiated to standardize bacteriology laboratory practices across the network.

Gram-negative isolates have been tested for colistin resistance using BMD test only by few centers; hence, data included in this report is of limited number of isolates. Data for vancomycin resistant *S. aureus* could not be included in this report as no site reported BMD testing data. Emergence of last resort drugs namely linezolid resistance to *S. aureus and Enterococcus* spp. and colistin resistance to gram-negative bacteria is of major concern and mandates strengthening local antimicrobial stewardship practices in the country.

VIII. Annexure: Medical College Laboratories under NARS-Net

National Programme on AMR Containment currently includes 29 AMR sentinel surveillance laboratories under NARS- Net (as on August 2020) which includes nine newly inducted sentinel sites (21-29). Laboratories 1-21 reported data during 01 January 2019 to 31 December 2019.

1. **BJ Medical College, Ahmedabad, Gujarat**
2. **BJ Medical College, Pune, Maharashtra**
3. **Government Medical College & Hospital, Chandigarh (UT)**
4. **GSVM Medical College, Kanpur, Uttar Pradesh**
5. **Lady Harding Medical College and associated hospitals, New Delhi**
6. **Mysore Medical College and Research Institute, Mysore, Karnataka**
7. **SMS Medical College, Jaipur, Rajasthan**
8. **VMMC and associated Safdarjung Hospital, New Delhi**
9. **Government Medical College, Thiruvananthapuram, Kerala**
10. **KAPV Govt. Medical College Hospital, Thiruchirapally, Tamil Nadu**
11. **Gauhati Medical College Hospital, Guwahati, Assam**
12. **NEIGRIHMS, Shillong, Meghalaya**
13. **MGM Medical College, Indore, Madhya Pradesh**
14. **Indira Gandhi Medical College, Shimla, Himachal Pradesh**
15. **Government Medical College, Aurangabad, Maharashtra**
16. **Osmania Medical College, Hyderabad, Telangana**
17. **Guntur Medical College, Guntur, Andhra Pradesh**
18. **Agartala Govt. Medical College, Agartala, Tripura**
19. **SCB Medical College, Cuttack, Odisha**
20. **Government Medical College & Hospital, Jammu, Jammu & Kashmir**
21. **Pt. BDS Post Graduate Institute of Medical Sciences, Rohtak, Haryana**
22. Rajendra Institute of Medical Sciences, Ranchi, Jharkhand
23. Indira Gandhi Institute of Medical Science, Patna, Bihar
24. Govt. Medical College, Haldwani, Uttarakhand
25. Pt. Jawahar Lal Nehru Medical College, Raipur, Chhattisgarh
26. Gandhi Medical College, Bhopal, Madhya Pradesh
27. Calcutta School of Tropical Medicine, Kolkata, West Bengal
28. GMERS Medical College and Hospital, Valsad, Gujarat
29. Lala Lajpat Rai Memorial Medical College, Meerut, Uttar Pradesh