
# National Antimicrobial Resistance Surveillance Network (NARS-Net India)

## Annual Report-2021

### Reporting Period- January to December 2020

**National Programme on AMR Containment**
**National Centre for Diseases 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

1st January to 31st December 2020

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# Acronyms

| | |
|---|---|
| **AMR** | Antimicrobial Resistance |
| **AST** | Antimicrobial Susceptibility Testing |
| **BMD** | Broth Microdilution |
| **CLSI** | Clinical & Laboratory Standards Institute |
| **CSV** | Comma delimited |
| **EQAS** | External Quality Assessment Scheme |
| **GLASS** | Global Antimicrobial Resistance and use Surveillance System |
| **IPD** | In-patient |
| **ICU** | Intensive Care Unit |
| **ID** | Identification |
| **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 |
| **NCDC** | National Centre for Disease Control |
| **NRL** | National Reference Laboratory |
| **OPD** | Outpatient |
| **OSBF** | Other Sterile Body Fluids |
| **PA** | Pus aspirate |
| **R I S** | Resistant Intermediate Sensitive |
| **TMP/SMX** | Trimethoprim Sulfamethoxazole |
| **SOP** | Standard Operating Procedure |
| VBA | Virtual Basic Application |
| **VRE** | Vancomycin Resistant *Enterococcus* species |
| **WHO** | World Health Organization |

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# 1. Executive Summary

This report of 2021 is the fourth annual report of the National AMR Surveillance Network (NARS-Net India) published by National Centre for Disease Control (NCDC). This report includes antimicrobial resistance (AMR) surveillance data of 7 priority pathogens viz. *Escherichia coli*, *Klebsiella* species, *Pseudomonas* species, *Acinetobacter* species, *Salmonella enterica* serotype Typhi and Paratyphi, *Staphylococcus aureus* and *Enterococcus* species received from 29 sentinel surveillance laboratories in 24 states/UTs. Antimicrobial susceptibility data of a total of 57,282 priority pathogens isolated from clinical samples of 55,688 unique patients has been reported from 1 January 2020- 31 December 2020. Out of 55,688 isolates, the highest number of isolates 41% are from urine specimens, followed by 34% from pus aspirate and other sterile body fluids (PA & OSBF), and 25% are from blood specimens.

Analysis of the data revealed *Escherichia coli* as the most commonly isolated pathogen (31%) in the AMR Surveillance data of the year 2020, followed by *Klebsiella* species (21%), *Staphylococcus aureus* (17%), *Pseudomonas* species (11%), *Enterococcus* species (10%), *Acinetobacter* species (9%) *and Salmonella enterica* serotype Typhi and Paratyphi (0.3%). *Escherichia coli* is the most common pathogen isolated among outpatients and inpatients, while *Klebsiella* species is the commonest pathogen isolated in ICU patients. *Escherichia coli is* the predominant isolate from urine samples (51%) and *S. aureus* is the most common pathogen isolated from both blood (31%) and PA & OSBF (28%).

The percentage of Methicillin resistant *S. aureus* (MRSA) isolates is 57% and the percentage resistance of *S. aureus* to linezolid is 1%. Linezolid resistance in *Enterococcus* spp. is observed to be 3%.

The resistance to 3$^{rd}$ and 4$^{th}$ generation cephalosporins among *E. coli* is 77% & 63%, respectively, similar to that observed in *Klebsiella* spp. 79% to 3$^{rd}$ generation and 69% to 4$^{th}$ generation cephalosporins. *Escherichia coli* and *Klebsiella* spp. also show higher rates of resistance to carbapenems. Four per cent resistance to colistin is observed in *E. coli* and *Klebsiella* spp. isolated and reported by the network laboratories under NARS-Net during 2020.

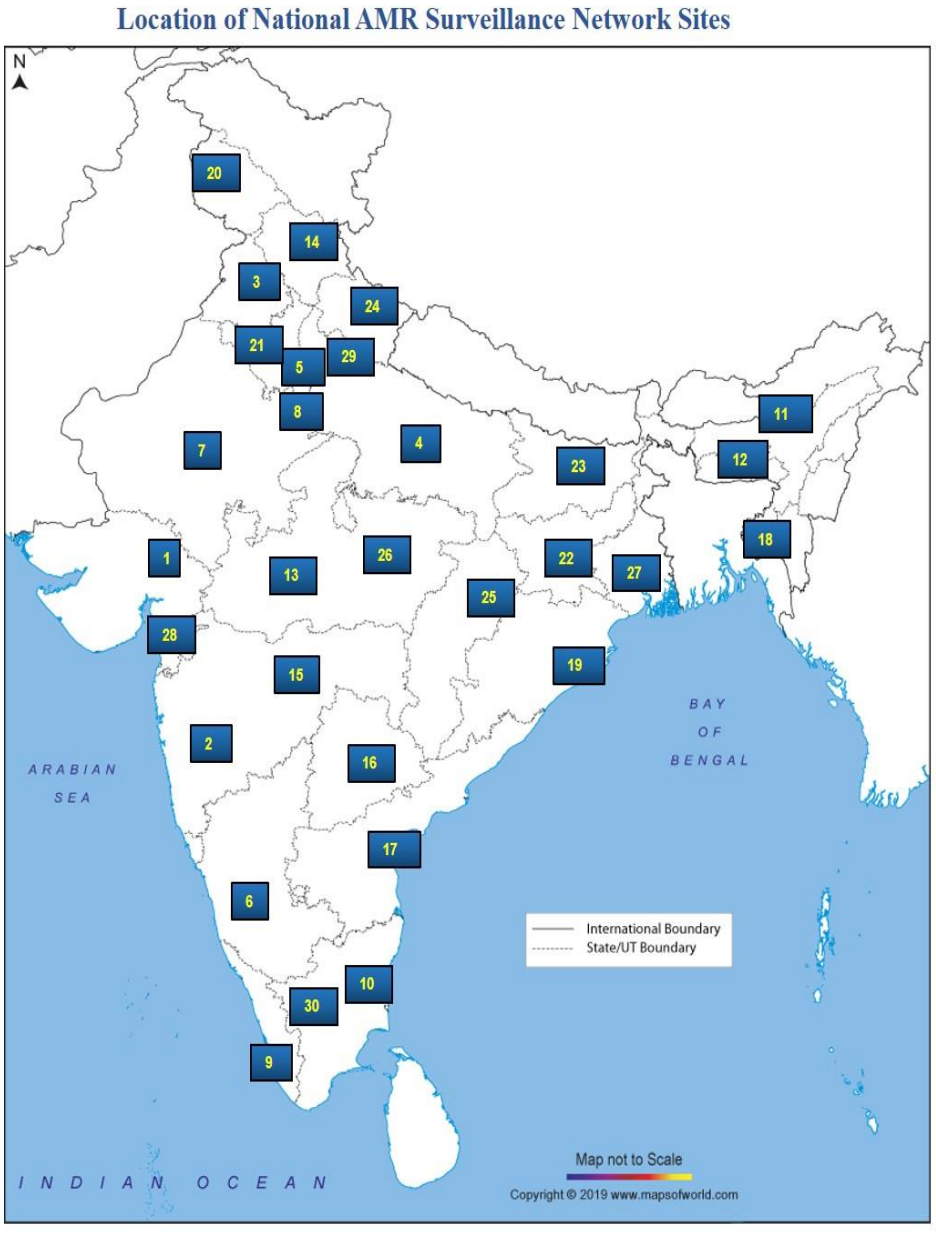
Among the anti-pseudomonal drugs, 60% isolates of *Pseudomonas* spp. in ICU patients are resistant to ceftazidime whereas Piperacillin/tazobactam resistance is observed in 49% of the isolates. The resistance to colistin in *Pseudomonas* spp. isolated from PA+OSBF and urine is 10%. Isolates of *Acinetobacter* spp. show more than 50% resistance to almost all the antibiotics tested except for minocycline to which 26% of strains are resistant.

Emergence of linezolid resistance in gram-positive pathogens and colistin resistance in the gram-negative pathogens is a matter of concern for public health.

# 2. National Antimicrobial Resistance Surveillance Network (NARS-Net)

The Ministry of Health and Family Welfare (MoHFW), Government of India (GoI) launched the "National Programme on AMR Containment" during the 12th five-year plan (2012-2017), National Centre for Disease Control, New Delhi being the coordinating agency for the programme. The primary objective of the programme was to strengthen lab capacity for AMR surveillance in state medical colleges in a phased manner to generate geographically well represented AMR surveillance data, which would act as evidence to develop strategies to contain the problem of AMR in the country. Over the years the objectives have been expanded to include AMR containment activities.

Under the National Programme on AMR Containment, National AMR Surveillance Network (NARS-Net) has been established which is a network of state medical college laboratories from across the country for generating AMR surveillance data through a sentinel surveillance system. NARS-Net currently includes surveillance of AMR in seven key priority pathogens responsible for the highest antibiotic resistance rates among bacteria that commonly cause human infections. These include *Staphylococcus aureus*, *Enterococcus* species, *Escherichia coli*, *Klebsiella* species, *Pseudomonas* species, *Acinetobacter* species, *Salmonella enterica* serotype Typhi and Paratyphi. MoHFW identified NCDC in July 2017 as the National coordinating centre for AMR surveillance and since then NARS-Net has been generating the National AMR Surveillance report annually and has been submitting data to WHO's Global Antimicrobial Resistance Surveillance System (GLASS). The annual report for the AMR surveillance data of 2017, 2018 and 2019 is available on the NCDC website. As of March 2021, NARS-Net included 30 Government Medical Colleges laboratories across 24 states/ UTs in India. (Fig. 1) Of these 30 sites, AMR surveillance data was received for the period of 1 January 2020 to 31 December 2020 from 29 medical college laboratories located in 24 states.




| Name of AMR Surveillance Network Sites | |
|---|---|
| 1 | BJMC Ahmedabad |
| 2. | BJMC Pune |
| 3. | GMC Chandigarh |
| 4. | GSVM Kanpur |
| 5. | LHMC Delhi |
| 6. | MMC &RI Mysore |
| 7. | SMS Jaipur |
| 8. | VMMC Safdarjung Delhi |
| 9 | GMC Trivandrum |
| 10 | KAPV Govt. MCH Tiruchirappalli |
| 11 | GMC Guahati |
| 12 | NEIGRIHMS Shillong |
| 13 | MGM MC Indore |
| 14 | IGMC Shimla |
| 15. | GMC Aurangabad |
| 16. | OMC Osmania |
| 17. | GMC Guntur |
| 18. | AGMC Agartala |
| 19. | SCB MC & H Cuttack |
| 20. | GMCH Jammu |
| 21. | BDS PGIMS Rohtak |
| 22. | RIMS Ranchi |
| 23. | IGIMS Patna |
| 24. | GMC Haldwani |
| 25 | JLNMC Raipur |
| 26. | GMC Bhopal |
| 27. | STM Kolkata |
| 28. | GMERS Valsad |
| 29. | LLRM Merrut |
| 30. | CMCH Coimbatore |

**Fig. 1** National AMR Surveillance Network (NARS-Net) Laboratories that have reported AMR Surveillance data to NCDC in the year 2020 (The above list is of sites included under NARS-Net as of March 2021; first 29 sites submitted AMR Surveillance data for the period of January to December 2020)

Most of the tertiary care hospitals in India during 2020 were converted to COVID (Corona Virus Disease) hospitals in 2020 due to the ongoing pandemic. This resulted in interruption of bacteriology laboratory functioning during the COVID-19 surge as the hospitals were overwhelmed with COVID-19 patients and laboratories focusing on SARS-CoV-2 diagnostics. Hence a comparison of antimicrobial resistance rates of 2020 with the previous years (2017, 2018, 2019) need to be interpreted with caution.

Under NARS-Net National Reference laboratory for bacterial pathogens has been established at NCDC. All network sites are mandated to submit to the NRL defined number of strains every quarter under the External Quality Assessment Scheme (EQAS). In addition, the sites also submit AMR alerts among priority pathogens with the duly filled form for confirmation to the NRL at NCDC. Feedback on EQAS and confirmation of alert strains is provided to the network labs. The sentinel surveillance laboratories under NARS-Net follow a standardised approach for AMR data collection, analysis, and reporting of AMR surveillance data using WHONET an open source microbiology data management software. Trainings are provided on AMR data management using the WHONET software and wet lab trainings on microbroth dilution (MBD) antimicrobial susceptibility testing for colistin and vancomycin. Online capacity building sessions were also held during 2020 for standardisation of techniques for clinical specimen collection, bacterial culture, identification of pathogens & their antimicrobial susceptibility testing (AST), including frequent trouble shooting sessions for WHONET data management. Onsite support visits are also conducted for streamlining AMR surveillance data management and assess the training needs. Feedback for the data submitted every quarter is provided using a standardised feedback tool to improve the completeness and quality of AMR data. Under NARS-Net Standard operating procedures and guidance documents have been developed for strengthening the network sites on routine AST techniques and improving internal quality control for AST testing in laboratories. These SoPs are reviewed on a regular basis.

# 3. Data Collection

This report includes AMR surveillance data from 29 network laboratories from 1 January 2020 to 31 December 2020 and includes data of 57,282 culture-positive clinical samples received at the sentinel surveillance sites during the year 2020 which were processed using conventional/automated culture and identification techniques and AST was done using disk diffusion/ broth microdilution/automated systems. This data was collected using the WHONET software, an open-source-offline microbiology data entry and analysis application database. NCDC provided training to all the NARS-Net laboratories to enter data into WHONET and backlink data from automated ID & AST systems/Laboratory Information Management Systems.

All sentinel sites submitted data quarterly after validation by the AMR nodal officers of the respective sites. As per programme guidelines, the data is to be submitted by the network sites within 15 days after each quarter:

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

Quarterly data was analysed at NCDC and feedback was provided. Also requested to re-submit the revised data if required. Under examination, the completeness of demographical/clinical data and the antibiotic susceptibility profile are checked. AST profile lists each organism and its AST result in numbers and percentage (%) RIS (Resistance, Intermediate, susceptible) to each antibiotic.

# 4. Data Analysis

## a. Data deduplication

Data de-duplication was done using the WHONET software to exclude duplicate findings for the same patient where several specimen cultures were collected during patient management so as to include one isolate per specimen per patient. Before starting the de-duplication process, variables containing information about the patient, location, specimen type, pathogen isolated for completeness of records was reviewed. Only the first ID, and AST result of unique patient isolate has been included in this report.

There might be occasions during the in-hospital stay that the same patient had repeated identifications of the same pathogens from repeat sample collection on different dates with different AST profiles. For example, if two blood cultures from the same patient yielded growth of *E. coli*, only the first AST profile was included in the report; if *E. coli* was detected in one culture and *K. pneumoniae* in the other, both results have been included. Both specimen data are included if *E. coli* is isolated from one blood culture and one urinary culture from the same patient.

## b. Priority Pathogens under surveillance in NARS- Net

The AMR data collected under the NARS-Net for the year 2020 is from 29 tertiary health care facilities (medical colleges) in 24 states; following are the seven priority pathogens and five clinical samples included under AMR surveillance (Table 1).

**Table 1.** Clinical specimens and priority pathogens included under AMR surveillance

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

X- specimen not collected for this pathogen

AMR surveillance data of 57,282 isolates submitted under NARS-Net was de-duplicated & analysed. After de-duplication, number of isolates from unique patients was 55,688. This is represented in following Fig. 2.

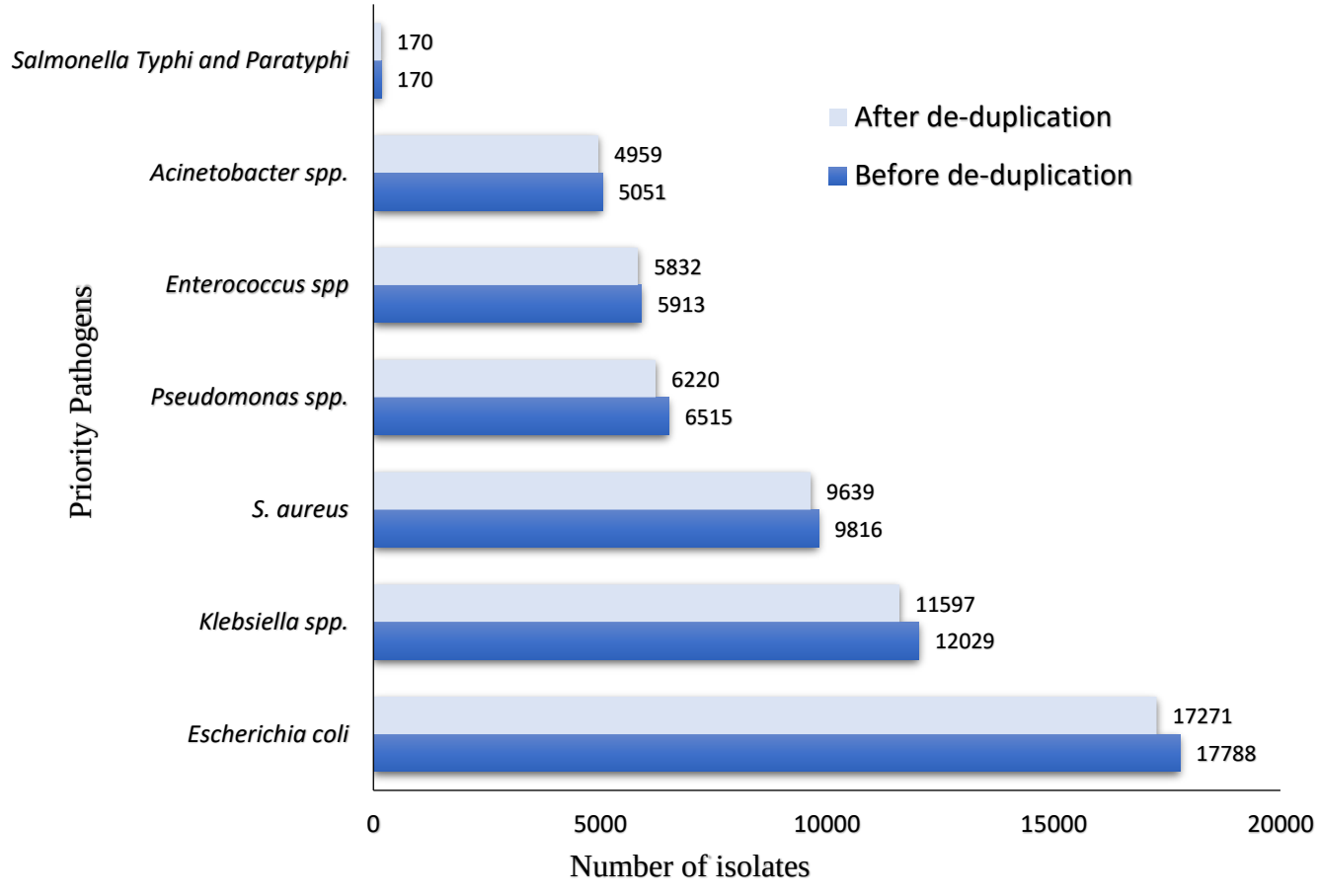



**Fig. 2** Priority bacterial pathogens before and after de-duplication

Total number of isolates from unique patients (after de-duplication) = 55,688

- Urine - 23,122 (41%)
- Pus Aspirates (PA) and Other Sterile body fluids (OSBF) – 19,044 (34%)
- Blood - 13,793 (25%)
- Stool – 1

*Escherichia coli* is the predominant isolate in the AMR Surveillance data for the year 2020 (31%) followed by *Klebsiella* spp. (21%), *S. aureus* (17%), *Pseudomonas* spp. and *Enterococcus* spp. (11% each), *Acinetobacter* spp. (9%) and *Salmonella* Typhi & Paratyphi (170 isolates) (Fig. 3)

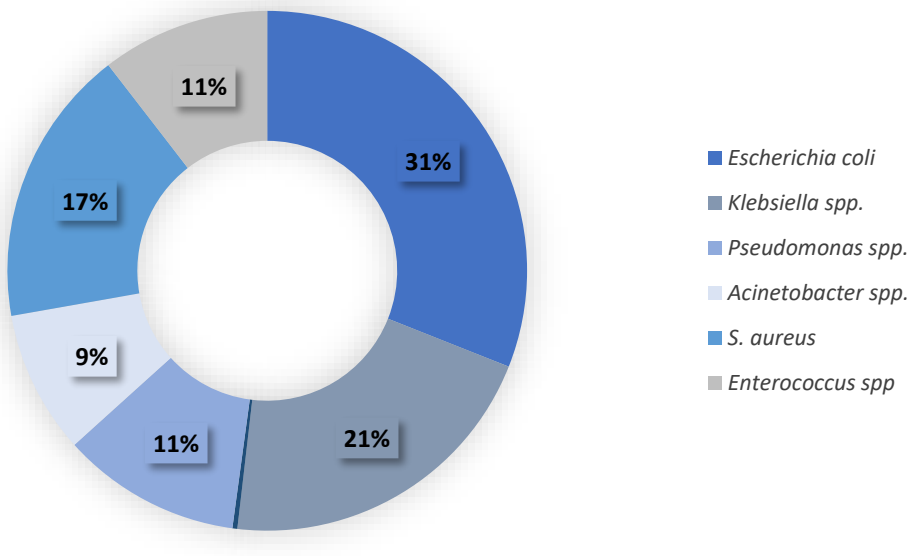



Fig. 3 Percentage distribution of isolates in AMR Surveillance data for the year 2020

Pathogens included in this report are predominantly isolated from urine specimens, followed by pus & other sterile body fluids and blood cultures (Fig. 4).

*Escherichia coli* (51%) is the most commonly isolated pathogen from urine, followed by *Klebsiella* spp. 20%, *Enterococcus* spp. 16%, *Pseudomonas* spp. 9% and *Acinetobacter* spp. 4% (Fig. 5).

The most commonly isolated pathogen from blood cultures is *S. aureus* 31% followed by *Klebsiella* spp. 23%, *Acinetobacter* spp. 16%, *Enterococcus* spp. 11%, *E. coli* 10%, *Pseudomonas* spp. 8%, *Salmonella serovar* Typhi and Paratyphi 0.3% (Fig. 5). All *Salmonella enterica* serovar Typhi and Paratyphi are isolated from blood except one isolate reported from stool sample (Table 2).

The most frequently reported pathogen from pus & other sterile body fluids is *S. aureus* 28%, followed by *E. coli* 22%, *Klebsiella* spp. 20%, *Pseudomonas* spp. 16%, *Acinetobacter* spp. 9% and *Enterococcus* spp. 4% (Table 2).

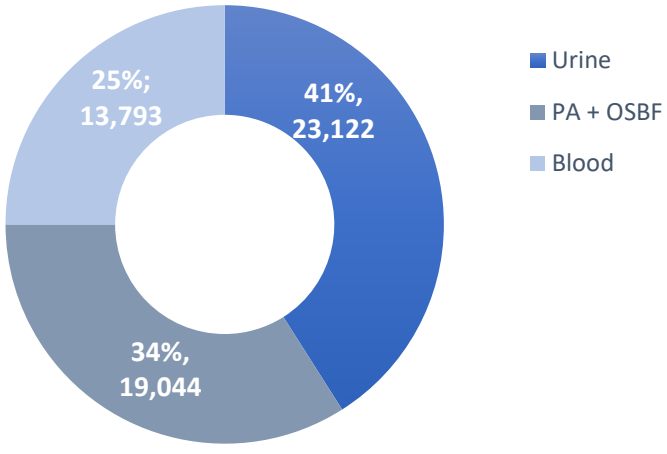



Fig. 4 Distribution of isolates by specimen type

**Table 2** Specimen wise isolation of Priority Pathogens

| Priority Pathogen | Blood (%) | Urine (%) | Pus aspirate and OSBF (%) | Stool |
|---|---|---|---|---|
| *Escherichia Coli* | 1,314 (10) | 11,820 (51) | 4,233 (22) | |
| *Klebsiella* spp. | 3,215 (23) | 4,717 (20) | 3,741 (20) | |
| *Salmonella* Typhi and Paratyphi | 169 (0.3) | | | 1 |
| *Pseudomonas* spp. | 1,141 (8) | 1,999 (9) | 3,101 (16) | |
| *Acinetobacter* spp. | 2,228 (16) | 9,73 (4) | 1,774 (9) | |
| *S. aureus* | 4,281 (31) | | 5,388 (28) | |
| *Enterococcus* spp | 1,445 (11) | 3,613 (16) | 807 (4) | |
| **Total** | **13,793** | **23,122** | **19,044** | **1** |

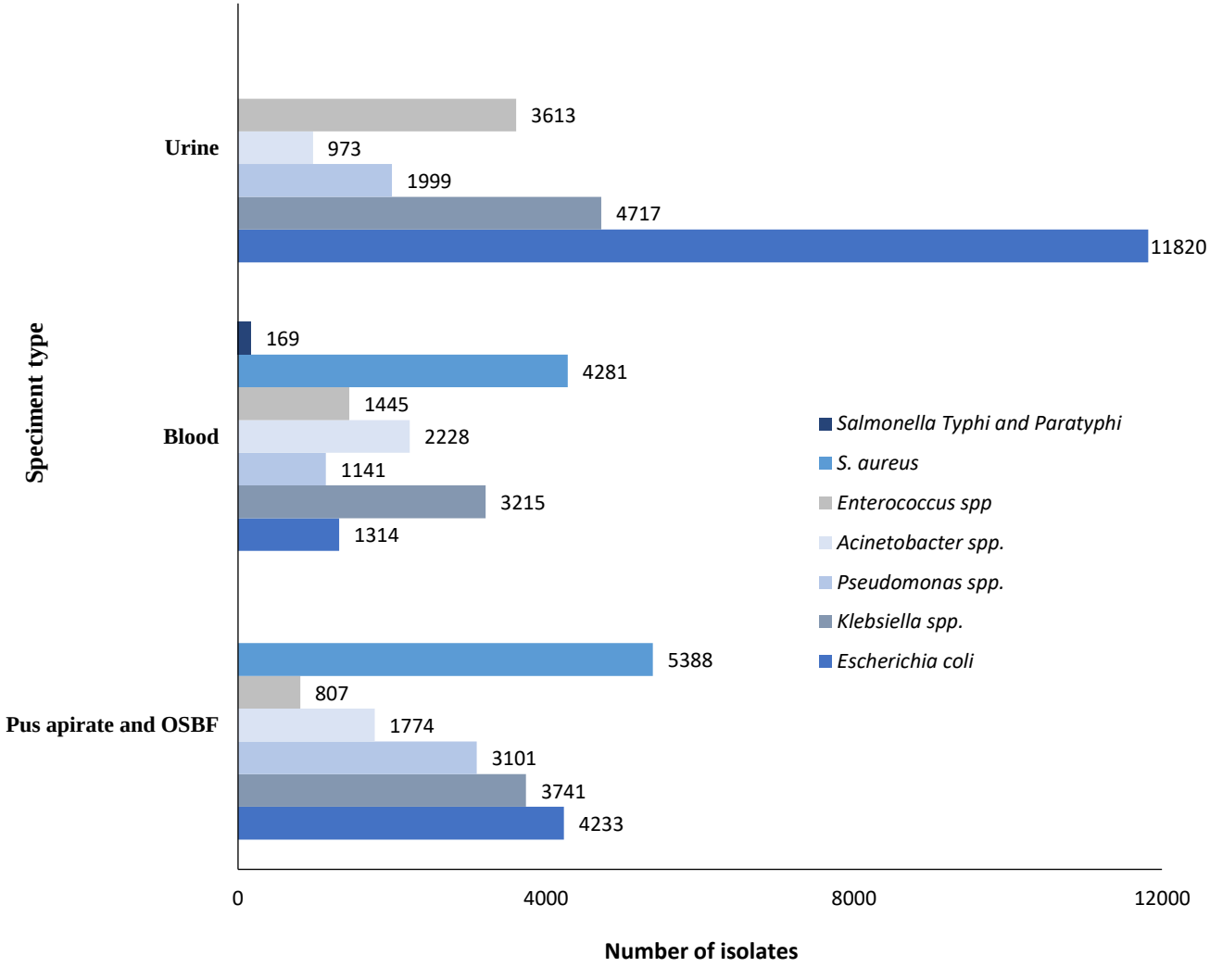



**Fig. 5** Specimen wise distribution of AMR surveillance Priority Pathogens

Number of isolates included in this report are more from male patients 55% (30,388) compared to female patients 45% (25,132) (Fig. 6). Out of total 55,688 unique patients, for 168 patients' gender and age both were not stated in the data submitted. Among males, highest number of isolates are from patients in 0-9 years age group (6,542) however in females highest number of isolates are from patients in 20-29 years age group (5,842) (Table 3).

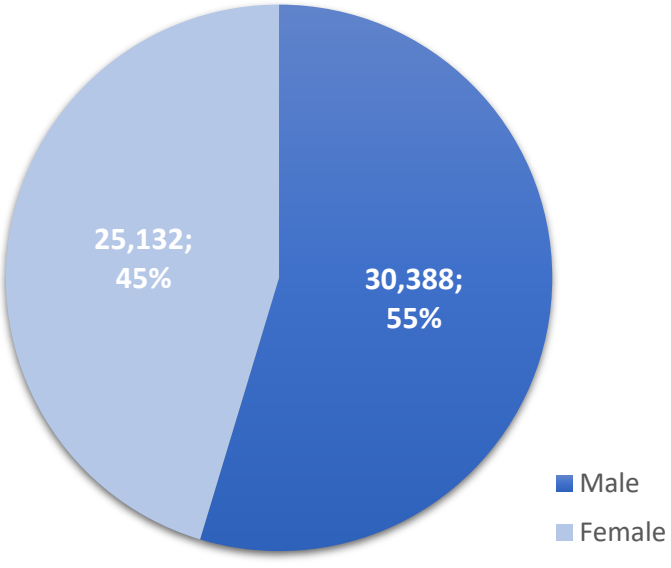



**Fig. 6** Overall distribution of isolates on the basis of gender

**Table 3** Gender and age-wise distribution of isolates

| Age (In years) | Male | Female |
|---|---|---|
| 0 to 9 | 6,435 | 4,536 |
| 10 to 19 | 2,351 | 1,909 |
| 20 to 29 | 3,462 | 5,842 |
| 30 to 39 | 3,828 | 3,562 |
| 40 to 49 | 3,850 | 2,494 |
| 50 to 59 | 3,627 | 2,366 |
| 60 & above | 5,229 | 3,062 |
| Unknown | 1,606 | 1,361 |
| **Total** | **30,388** | **25,132** |

In the year 2020, the highest number of isolates are from IPD 34,125 (63%), followed by OPD 12,373 (23%), followed by ICU 7,558 (14%) (Fig. 7).

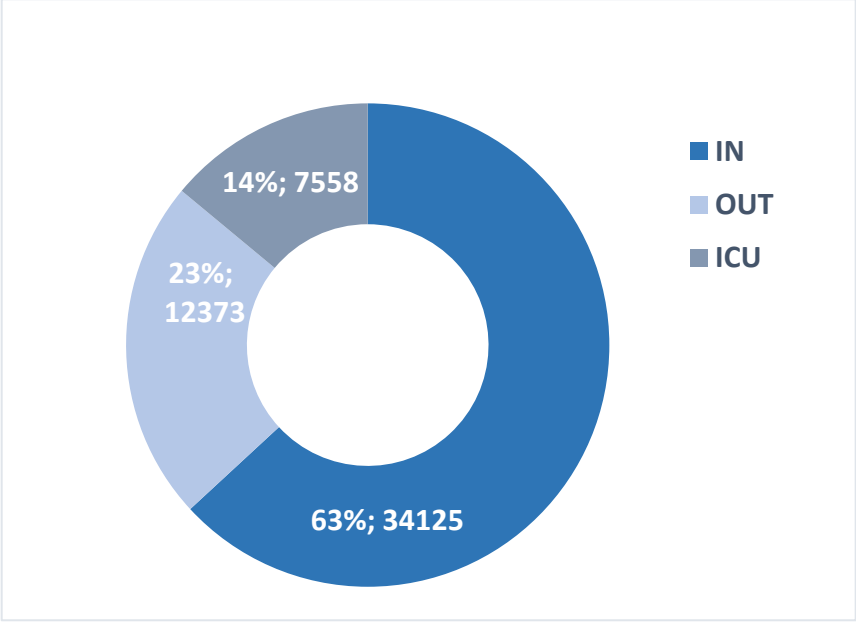



**Fig. 7** Location-wise distribution of isolates

**Table 4.** Location-wise distribution of Priority Pathogens

| Priority Pathogens | ICU (%) | IPD (%) | OPD (%) |
|---|---|---|---|
| ***Escherichia Coli*** | 1,453 (19) | 9,763 (29) | 5,110 (41.3) |
| ***Klebsiella* spp.** | 1,941 (25.8) | 7,077 (21) | 2,368 (19) |
| ***Salmonella* Typhi and Paratyphi** | 15 (0.2) | 106 (0.3) | 46 (0.4) |
| ***Pseudomonas* spp.** | 680 (9) | 3,974 (11.7) | 1,422 (11.5) |
| ***Acinetobacter* spp.** | 1,311 (17) | 3,042 (9) | 520 (4.2) |
| ***S. aureus*** | 1,233 (16) | 6,596 (19) | 1,678 (13.6) |
| ***Enterococcus* spp** | 925 (12) | 3,567 (10) | 1,229 (10) |
| **Total (55,688)** | **7,558 (14)** | **34,125 (63)** | **12,373 (23)** |

Among IPD patients, highest number of isolates are of *E coli* 29% followed by *Klebsiella* spp. 21%, *S. aureus* 19%, *Pseudomonas* spp. 11.7%, *Enterococcus* spp. 10%, *Acinetobacter* spp. 9% and *Salmonella* Typhi and Paratyphi 0.3% (Table 4)

Predominantly isolated pathogen from OPD patients is *E. coli* 41.3%, followed by *Klebsiella* spp. 19%, *S. aureus* 13.6 %, *Pseudomonas* spp. 11.5%, *Enterococcus* spp. 10%, *Acinetobacter* spp. 4.2% and *Salmonella* Typhi and Paratyphi 0.4% (Table 4; Fig. 8).

Highest number of isolates from ICU patients are of *Klebsiella* spp. 25.8%, followed by *E. coli* 19%, *Acinetobacter* spp. 17%, *S. aureus* 16%, *Enterococcus* spp. 12%, *Pseudomonas* spp. 9% and *Salmonella* Typhi and Paratyphi 0.2% (Table 4; Fig. 8).

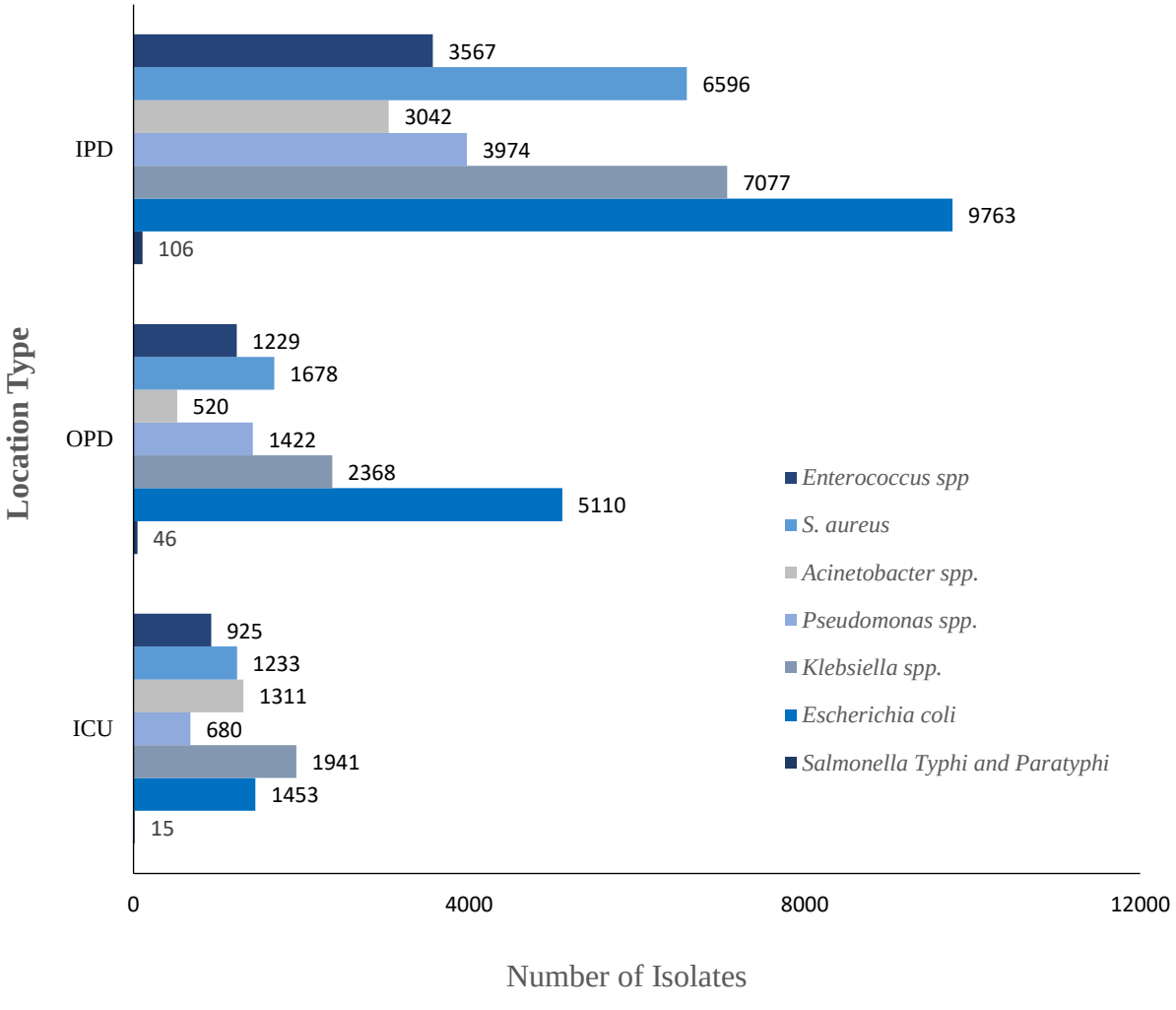



**Fig. 8** Location wise isolation of different Priority Pathogens

# 5. AMR profile of priority pathogens

The data collected under National AMR Surveillance Network (NARS-Net) is for selected antibiotics only as per the NCDC AMR surveillance data management Standard Operating procedure (SoP). This AMR surveillance data is from patients visiting out-patient departments of the hospitals and from patients admitted to the in-patient departments & intensive care units. Because of the COVID-19 pandemic all network site laboratories were primarily engaged in COVID-19 testing, hence the number of isolates for which AST data has been submitted for the year 2020 is less than the previous years.

## a. Gram-Positive Cocci

Antimicrobial susceptibility data of a total 15,729 gram-positive isolates was reported from 15,471 unique patients during 2020.

### *Staphylococcus aureus*

*Staphylococcus aureus* constituted 17% of all the isolates reported by network sites to NCDC (Fig. 3). The 9,816 *S. aureus* isolates have been reported from 9,639 unique patients (Fig. 2). During 2020, *S. aureus* has been predominantly isolated from in-patients and most commonly from the blood culture specimens (Table 2 and Fig. 5). It is observed that the proportion of MRSA among *Staphylococcus aureus* continued to be high for the past three years: 2017 - 2,078 isolates (56%), 2018 - 6,682 isolates (63%), 2019 - 6,994 isolates (59%) and 2020 - 4,664 isolates (57%) (Fig. 9).

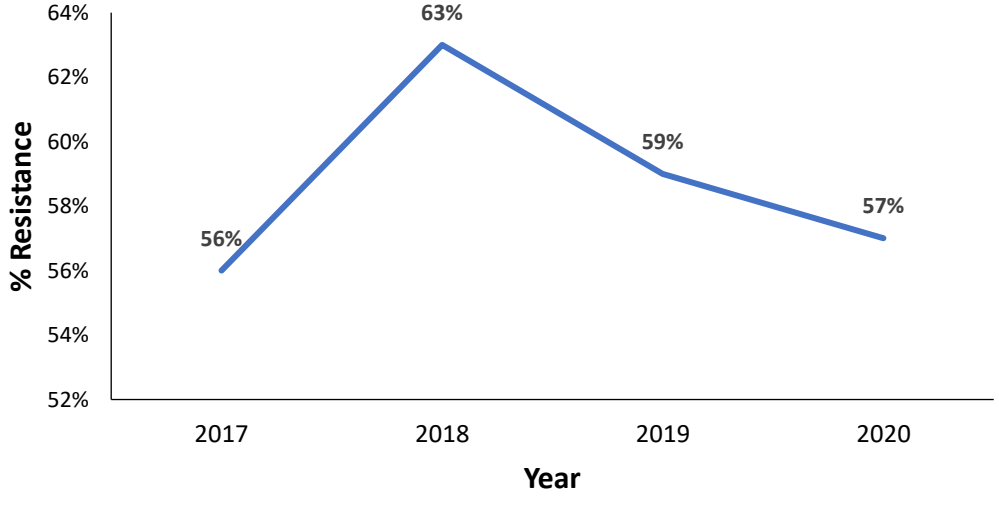



**Fig 9.** Trends in Methicillin Resistant *Staphylococcus aureus* (MRSA) from 2017 to 2020

MRSA rates differ based on the source of isolation. Methicillin resistance is highest among *S. aureus* isolated from blood cultures that is 64%, followed by 52% in isolates from PA+OSBF (Table 5). Ciprofloxacin resistance is seen in 62% of *S. aureus* isolates from blood culture specimens and in 72% of *S. aureus* isolates from PA & OSBF (Table 5). Resistance to erythromycin is 68% in blood culture isolates and 50% in isolates from PA & OSBF. Gentamicin resistance is observed in 26% of isolates from blood culture specimens and in 22% isolates from PA & OSBF specimens. Location type wise resistance profile of *Staphylococcus aureus* isolated from blood culture specimens is shown in Fig.10. Overall resistance to linezolid in *S. aureus* isolates reported during 2020 is 1%. The linezolid resistance trend from 2017 to 2020 is shown in Fig. 11.

**Table 5.** Resistance profile of *Staphylococcus aureus* (N= 9,639)

| Antibiotic tested | Blood + PA + OSBF (N=9,639) | | | Blood (N=4,281) | | | PA + OSBF (N=5,388) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R |
| Cefoxitin | 8,203 | 4,664 | 57 | 3,650 | 2,319 | 64 | 4,580 | 2,357 | 52 |
| Gentamicin | 8,011 | 1,920 | 24 | 3,572 | 929 | 26 | 4,467 | 1,001 | 22 |
| Ciprofloxacin | 7,110 | 4,798 | 68 | 3,047 | 1,898 | 62 | 4,087 | 2,922 | 72 |
| TMP/SMX | 6,872 | 2,947 | 43 | 2,866 | 1,467 | 51 | 4,032 | 1,493 | 37 |
| Clindamycin | 8,285 | 2,232 | 27 | 3,629 | 1,221 | 34 | 4,684 | 1,019 | 22 |
| Erythromycin | 8,086 | 4,675 | 58 | 3,629 | 2,451 | 68 | 4,487 | 2,244 | 50 |
| Linezolid | 8,083 | 79 | 1 | 3,519 | 26 | 1 | 4,592 | 43 | 1 |
| Doxycycline | 5,489 | 725 | 13 | 2,638 | 24 | 12 | 2,867 | 402 | 14 |

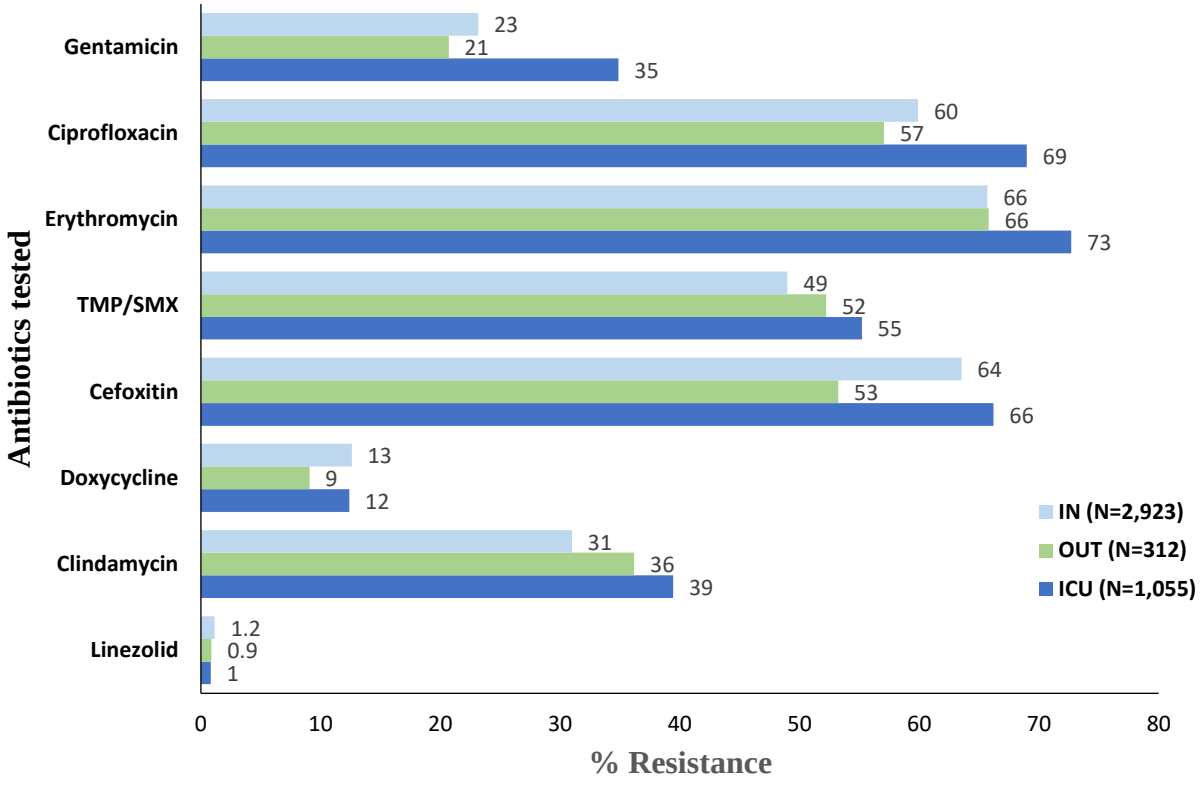



**Fig. 10** Location type wise resistance profile of *Staphylococcus aureus* isolated from blood culture specimens

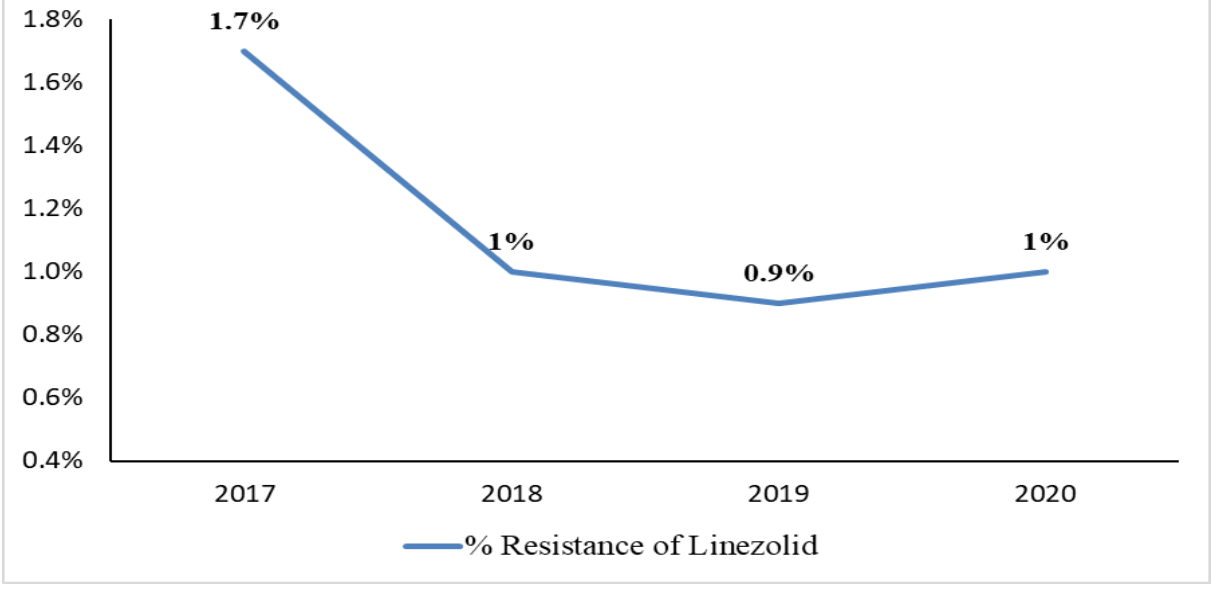



**Fig. 11** Trend of linezolid resistance in *Staphylococcus aureus* reported under NARS-Net (2017 to 2020)

CLSI guidelines recommend that the susceptibility of vancomycin against *S. aureus* be tested using a broth microdilution test. However, similar to the previous year, none of the sites during 2020 reported MIC results for vancomycin using broth microdilution test against *S. aureus*. Therefore, to troubleshoot the challenges of the sites in performing broth microdilution test, NCDC conducted hands-on training on broth microdilution technique for susceptibility testing of vancomycin and colistin in February 2020. The data of vancomycin AST for *S. aureus* is not included as the AST results by BMD were not available for the data-reporting period.

**Table 6 -** Overall resistance profile of *Staphylococcus aureus* isolates to different antimicrobials

| Antibiotic | % Resistance |
|---|---|
| Cefoxitin | 57% |
| Gentamicin | 24% |
| Ciprofloxacin | 68% |
| Linezolid | 1% |

## *Enterococcus* species

*Enterococcus* spp. constitutes 11% of all the isolates in the 2020 data (Fig. 3). Total 5,913 isolate data is reported from 5,832 unique patients, and the resistance profile details are given in Table 7. Similar to *S. aureus*, > 70 % resistance is observed in blood culture isolates of *Enterococcus* spp. to ampicillin, ciprofloxacin and erythromycin (Table 7). In annual report of the year 2018, the proportion of Vancomycin resistant *Enterococcus* (VRE) is 18% whereas in 2019 it reduced to 13%and in the 2020 occurrence of VRE is further reduced to 9% which may be attributed to AST data of less number of isolates submitted by the network sites due to COVID-19 pandemic.

Of 5,832 enterococci analysed, highest rate of resistance is observed in ciprofloxacin (80%) followed by erythromycin (77%), ampicillin (63%), tetracycline (58%), high level gentamicin (45%), doxycycline (40%) (Fig. 12).

Nine percent of the *Enterococcus* spp. tested for antimicrobial susceptibility are resistant to vancomycin and 3% of the isolates are resistant to linezolid. Compared to the previous three years (5-6 %), resistance to linezolid in *Enterococcus* species is lowered to 3% this year. (Fig. 15)

In urine, blood and PA & OSBF high resistance is found for erythromycin (84%, 74% & 72% respectively) and ciprofloxacin (82%, 74% & 79% respectively). In urine, blood and PA & OSBF lower resistance is found for vancomycin (10%, 10% & 7% respectively) (Table 7). Among ICU

and IPD patients, higher percentage of VREs are found in urine specimens than in blood and OSBF specimens (Fig. 13; Fig. 14) While higher percentage of linezolid resistant Enterococci are isolated from blood and PA+OSBF (5%) specimens of ICU patients than that from urine specimens (2%) (Fig. 13; Fig. 14).

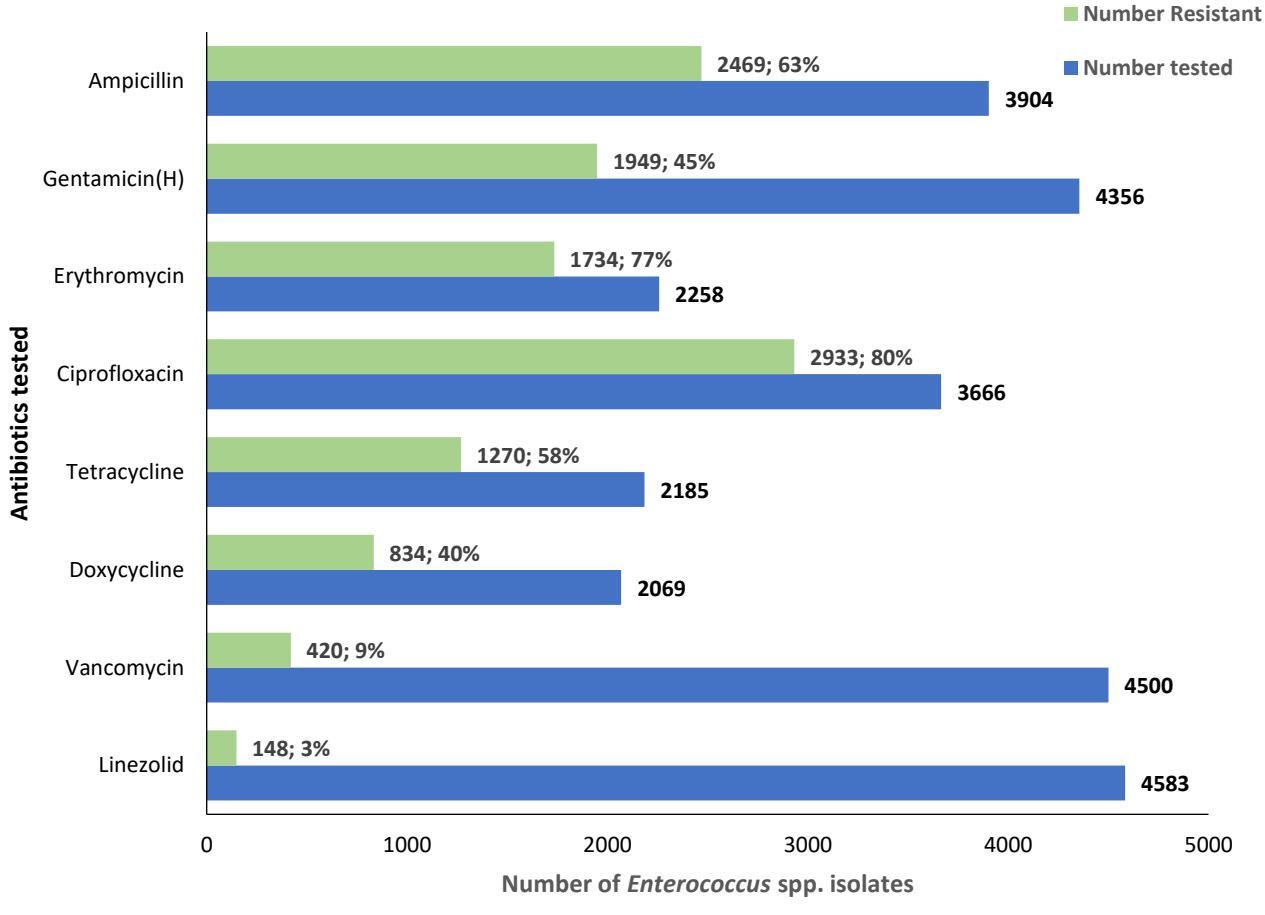



**Fig. 12** Resistance profile of *Enterococcus* species (N=5,832)

**Table 7.** Specimen wise resistance profile of *Enterococcus* species

| Antibiotic tested | PA + OSBF (N=807) | | | Blood (N=1,445) | | | Urine (N=3,613) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number tested | Number Resistant | % R | Number tested | Number Resistant | % R | Number tested | Number Resistant | % R |
| Ampicillin | 582 | 345 | 59 | 855 | 604 | 71 | 2,491 | 1,542 | 62 |
| Gentamicin-High | 616 | 198 | 32 | 981 | 390 | 40 | 2,785 | 1,380 | 50 |
| Ciprofloxacin | 452 | 358 | 79 | 657 | 483 | 74 | 2,573 | 2,107 | 82 |
| Erythromycin | 552 | 396 | 72 | 975 | 725 | 74 | 748 | 628 | 84 |
| Linezolid | 669 | 24 | 4 | 1,047 | 39 | 4 | 2,895 | 85 | 3 |
| Vancomycin | 656 | 47 | 7 | 1,004 | 95 | 10 | 2,867 | 281 | 10 |
| Doxycycline | 472 | 207 | 44 | 825 | 272 | 33 | 791 | 362 | 46 |
| Tetracycline | 146 | 96 | 66 | 378 | 185 | 49 | 1,680 | 1,001 | 60 |

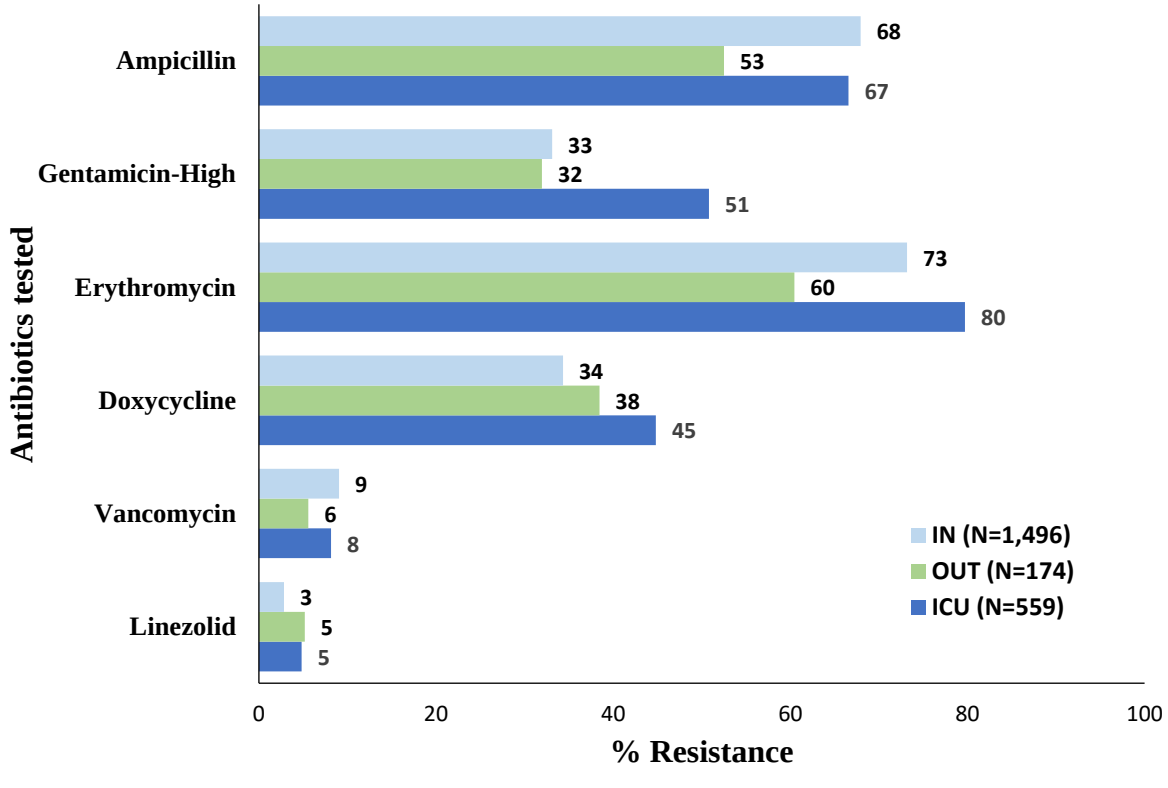



**Fig. 13** Resistance profile of *Enterococcus* species isolated from blood and PA & OSBF from different location types in healthcare facilities

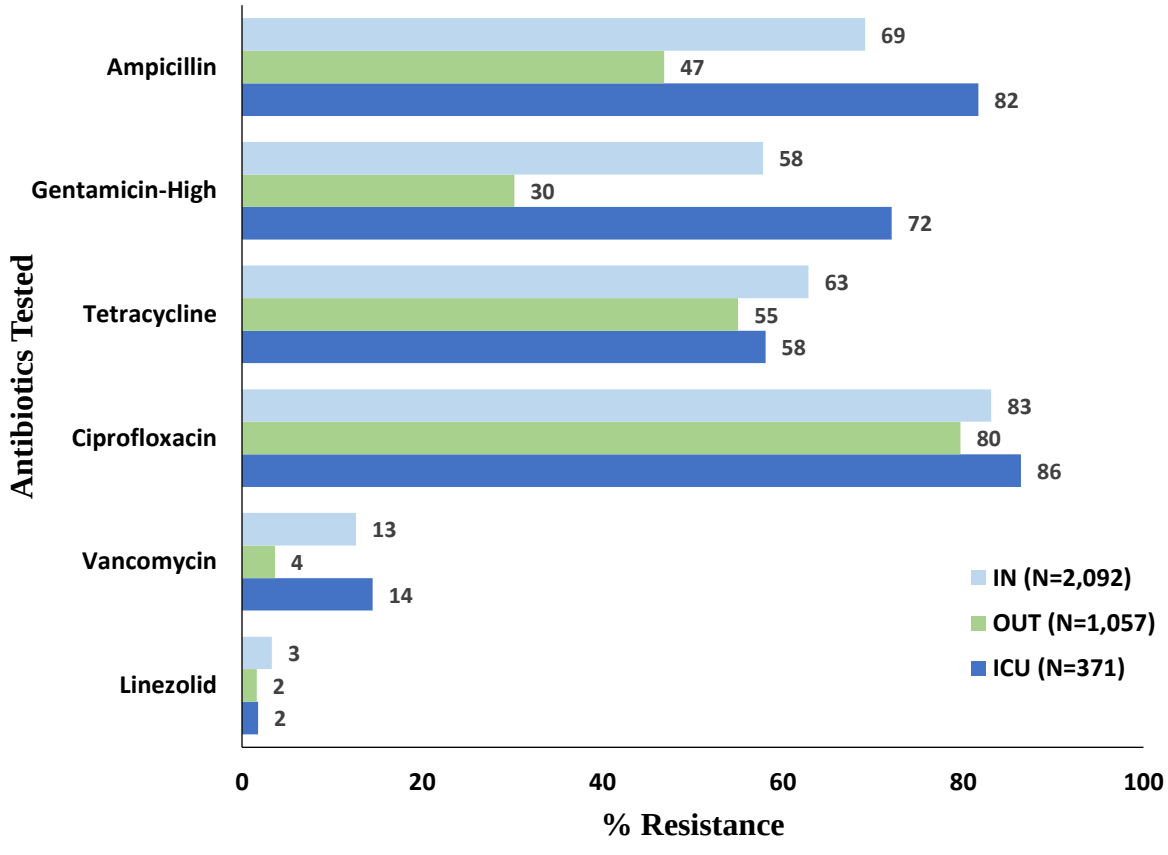



**Fig. 14** Resistance profile of *Enterococcus* species isolated from urine specimens from different location types in healthcare facilities

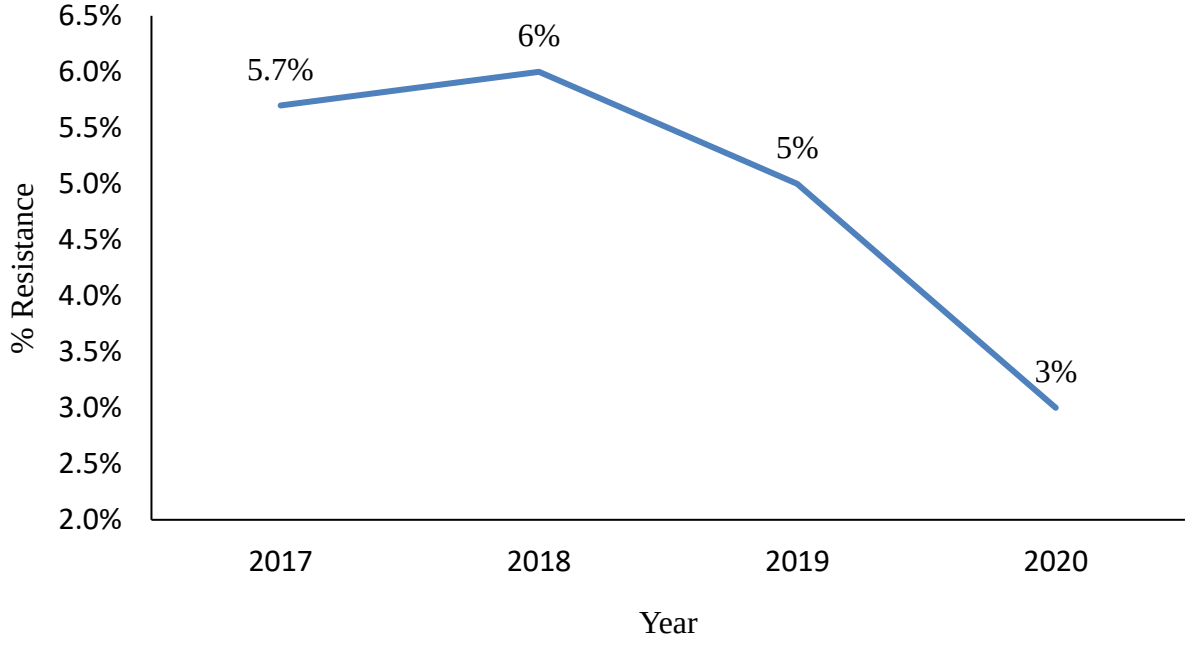



**Fig. 15** Trend of linezolid resistance in *Enterococcus* species from 2017 to 2020

# b. Gram negative bacilli

Gram-negative pathogens included for AMR surveillance under NARS-NET are among the commonest cause of bacterial infections in patients attending the healthcare facilities. The gram-negative priority pathogens included under the NARS-NET are *E. coli, Klebsiella* spp., *Pseudomonas* spp., *Acinetobacter* spp., *Salmonella enterica* serotype Typhi and Paratyphi. In 2017, 2018 & 2019, gram-negative isolates were 18,536, 34,499 & 54,029, respectively; thus, the number of reported isolates by network sites has increased over the years. In the year 2020, total 41,553 gram-negative pathogens are isolated from 40,217 unique patients from 29 network sites.

## i. Enterobacteriaceae

Enterobacterales i.e. *E. coli*, *Klebsiella* spp. and *Salmonella* Typhi and Paratyphi, constitute the majority 29,987 (52%) (Fig. 3) of the overall priority pathogens in this annual AMR surveillance report. Similarly, in previous years reports Enterobacteriaceae accounts for the highest number of priority pathogens. Of these 29,987 Enterobacteriaceae isolates received from 29 sentinel sites, 29,038 are from unique patients

### *Escherichia coli*

Total 17,788 *E. coli* isolates were reported from 17,271 unique patients. The highest number of *E coli* was reported from urine samples, followed by PA & OSBF and blood (Table 8). Similar resistance pattern is seen in isolates from urine, blood and PA & OSBF for all antimicrobials. (Fig. 16)

In urinary tract infection patient's beta-lactam antibiotic resistance is high, it is 87% to ampicillin followed by 77% to cefotaxime, 62% to cefepime, 27% to ertapenem and 22% to imipenem. Among non-beta-lactam antibiotics, 70% resistance was observed to ciprofloxacin, 63% to Trimethoprim-Sulfamethoxazole (TMP/SMX) and 12% to nitrofurantoin (Table 8).

Similarly, in *E. coli* isolates from blood, percentage resistance to beta-lactam antibiotics, i.e. 86% to ampicillin, 80% to cefotaxime, 67% to cefepime, 40% to ertapenem, 32% to imipenem. Among non-beta-lactam antibiotics, 63% resistance to ciprofloxacin and 59% to TMP/SMX is observed (Table 8).

In PA & OSBF isolates of *E. coli* resistance reported is 89% to ampicillin followed by 79% to cefotaxime, 63% to cefepime, 31% to ertapenem, 24% to imipenem, 70% to ciprofloxacin and 64% to TMP/SMX (Table 8).

The colistin susceptibility testing has been done using the broth microdilution method as per CLSI document M02 and M100, though for a limited number of isolates. Overall colistin resistance in *E. coli* isolates is 3.1%, 6.3% in urinary isolates, 1.5% in isolates from PA & OSBF and 0.6% in isolates from blood (Table 8). Resistance profile of *E. coli* isolates from blood, urine, PA & OSBF from different location types is shown in Fig. 17.

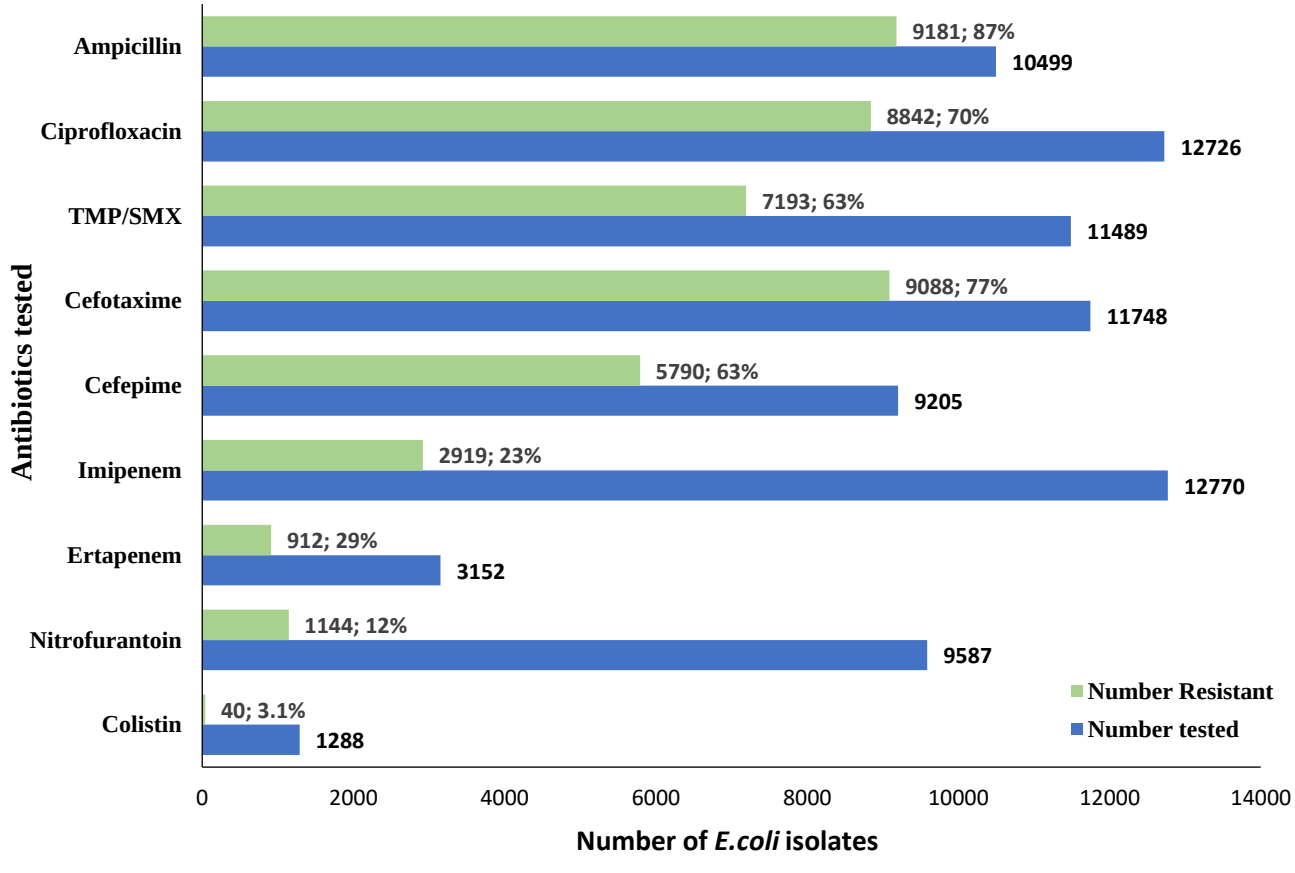



**Fig. 16** Resistance profile of *E. coli* (N=17,271)

**Table 8.** Specimen wise resistance profile of *E. coli* (N=17,271 )

| Antibiotic tested | PA + OSBF (N=4,233) | | | Blood (N=1,314) | | | Urine (N=11,820) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R |
| Ampicillin | 2,590 | 2,291 | 89 | 800 | 688 | 86 | 7,188 | 6,279 | 87 |
| Cefotaxime | 2,946 | 2,340 | 79 | 821 | 654 | 80 | 8,068 | 6,169 | 77 |
| Cefepime | 2,332 | 1,468 | 63 | 856 | 573 | 67 | 6,097 | 3,807 | 62 |
| Ertapenem | 900 | 275 | 31 | 272 | 109 | 40 | 1,980 | 528 | 27 |
| Imipenem | 3,400 | 801 | 24 | 1,049 | 330 | 32 | 8,412 | 1,815 | 22 |
| Ciprofloxacin | 3,063 | 2,156 | 70 | 948 | 600 | 63 | 8,796 | 6,156 | 70 |
| TMP/SMX | 2,522 | 1,613 | 64 | 852 | 505 | 59 | 8,197 | 5,136 | 63 |
| Nitrofurantoin | 154 | | | | | | 9,376 | 1,113 | 12 |
| Colistin | 454 | 7 | 1.5 | 345 | 2 | 0.6 | 493 | 31 | 6.3 |

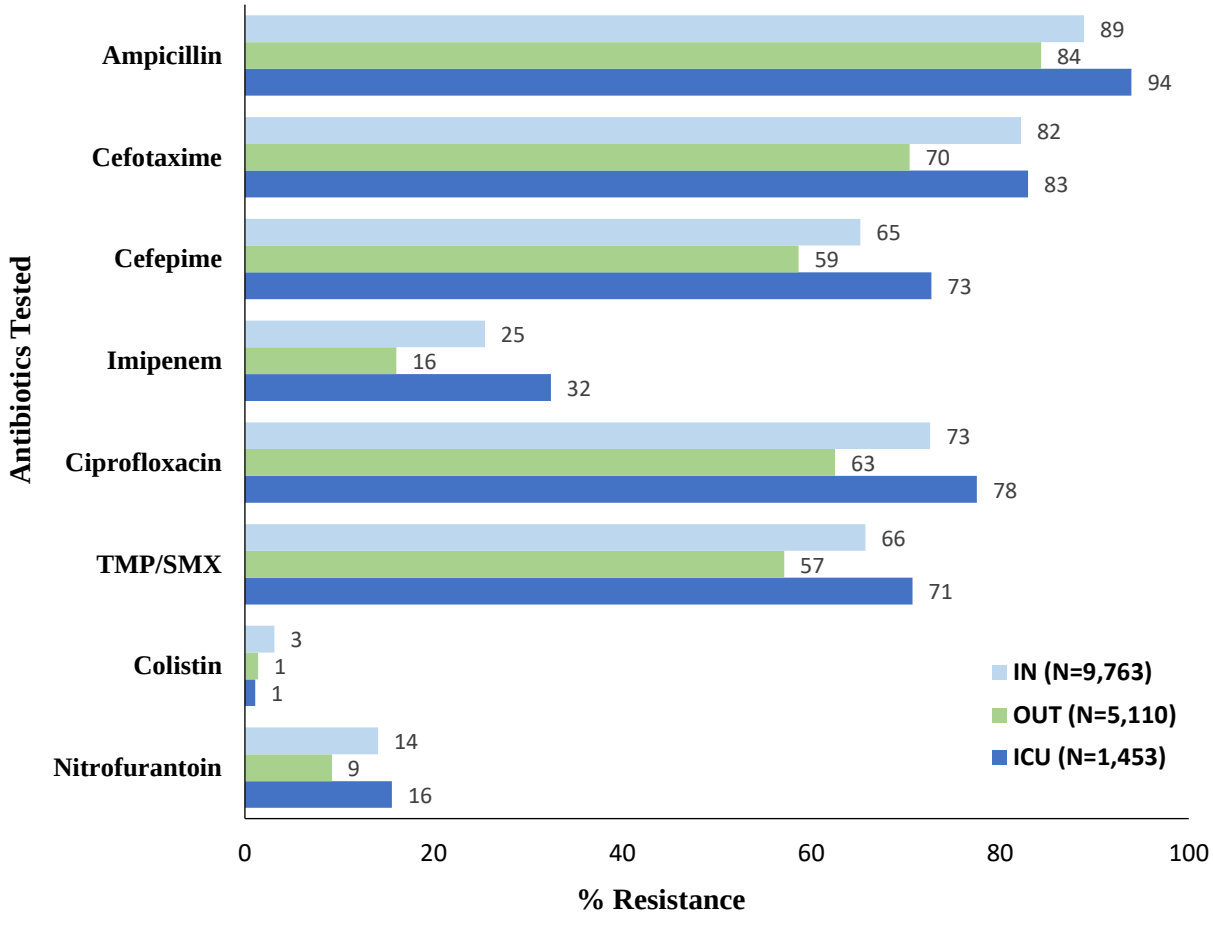



**Fig. 17** Resistance profile of *E. coli* isolates from blood, urine, PA & OSBF from different location types in healthcare facilities

## *Klebsiella* species

Total 12,029 *Klebsiella* spp. isolates were reported from 11,597 unique patients in the year 2020. Similar to the *E. coli* highest number of *Klebsiella* spp. are reported from urine samples followed by PA & OSBF and blood (Fig. 5). Beta-lactam antibiotic resistance observed among blood culture isolates is 90% to cefotaxime, 80% to cefepime, 59% to ertapenem, 55% to imipenem and 53% to meropenem. For beta lactam + beta lactam inhibitor piperacillin/tazobactam 69% resistance is reported (Table 9)

For urinary isolates, beta lactam antibiotic resistance in urine is 73% (2,551) to cefotaxime, 62% to cefepime, 38% to ertapenem, 30% to imipenem, 28% to meropenem. Resistance of Piperacillin-Tazobactam is 41% (Table 9).

Beta lactam antibiotic resistance in PA & OSBF isolates is 79% to cefotaxime, 69% to cefepime, 43 % to imipenem, 43%to meropenem, 42% to ertapenem. 64% isolates are resistant to beta lactam + beta lactam inhibitor piperacillin/tazobactam (Table 9). Amikacin resistance is observed in 51% isolates from PA & OSBF and blood each and in 34% isolates from urine.

The colistin susceptibility testing has been done using the broth microdilution method as per CLSI document M02 and M100, though for a limited number of isolates. Overall resistance to colistin observed in *Enterococcus* isolates is 4%, in urinary isolates it is 6.3%, in isolates from PA & OSBF it is 1.5% and in blood culture isolates it is 0.6% (Table 9).

*Klebsiella* spp. isolates showed more than 40% resistance to all the antibiotics tested except for colistin to which 4% resistance is observed. (Fig. 18). *Klebsiella* species showed alarmingly high resistance to 3$^{rd}$ and 4$^{th}$ generation cephalosporins (91% to cefotaxime, 83% to cefepime) and carbapenem (59% to imipenem) in ICU patients (Fig. 19).

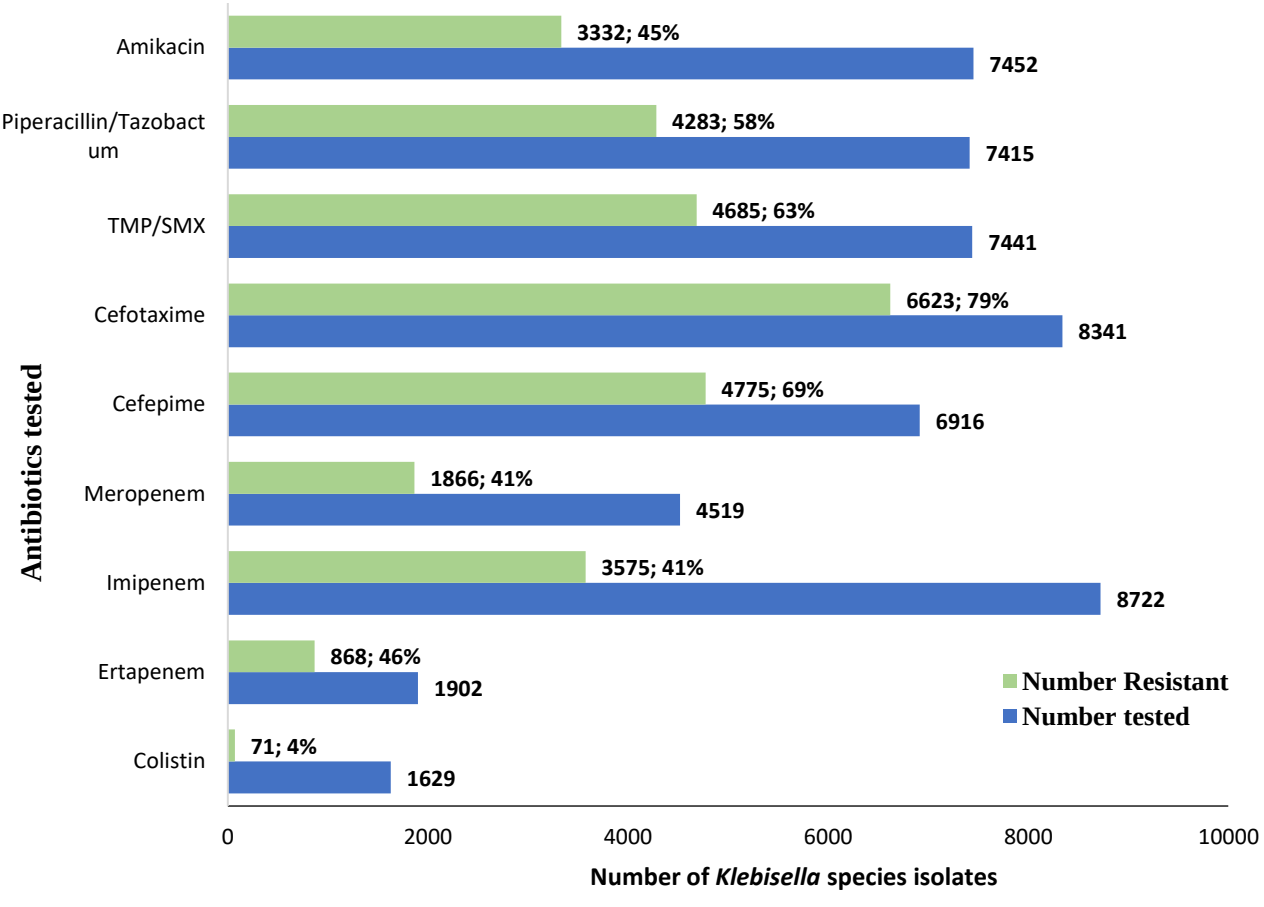



**Fig. 18** Resistance profile of *Klebsiella* species (N= 11,597)

**Table 9.** Specimen wise resistance profile of *Klebsiella* species (N= 11,597)

| Antibiotic tested | PA + OSBF (N=3,741) | | | Blood (N=3,215) | | | Urine (N=4,717) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R |
| **Cefotaxime** | 2,755 | 2,173 | 79 | 2,181 | 1,961 | 90 | 3,476 | 2,551 | 73 |
| **Cefepime** | 2,438 | 1,670 | 69 | 1,917 | 1,536 | 80 | 2,629 | 1,622 | 62 |
| **Ertapenem** | 706 | 297 | 42 | 548 | 323 | 59 | 650 | 249 | 38 |
| **Imipenem** | 3,138 | 1,338 | 43 | 2,312 | 1,265 | 55 | 3,346 | 1,008 | 30 |
| **Meropenem** | 1,705 | 731 | 43 | 1,416 | 754 | 53 | 1,413 | 394 | 28 |
| **Amikacin** | 2,606 | 1,326 | 51 | 2,143 | 1,102 | 51 | 2,760 | 939 | 34 |
| **Ciprofloxacin** | 2,882 | 1,854 | 64 | 2,257 | 1,425 | 63 | 3,366 | 2,003 | 60 |
| **TMP/SMX** | 2,475 | 1,632 | 66 | 1,939 | 1,248 | 64 | 3,097 | 1,861 | 60 |
| **Piperacillin/ Tazobactam** | 2,840 | 1,805 | 64 | 2,274 | 1,558 | 69 | 2,354 | 960 | 41 |
| **Colistin** | 588 | 37 | 6 | 814 | 12 | 2 | 232 | 16 | 7 |

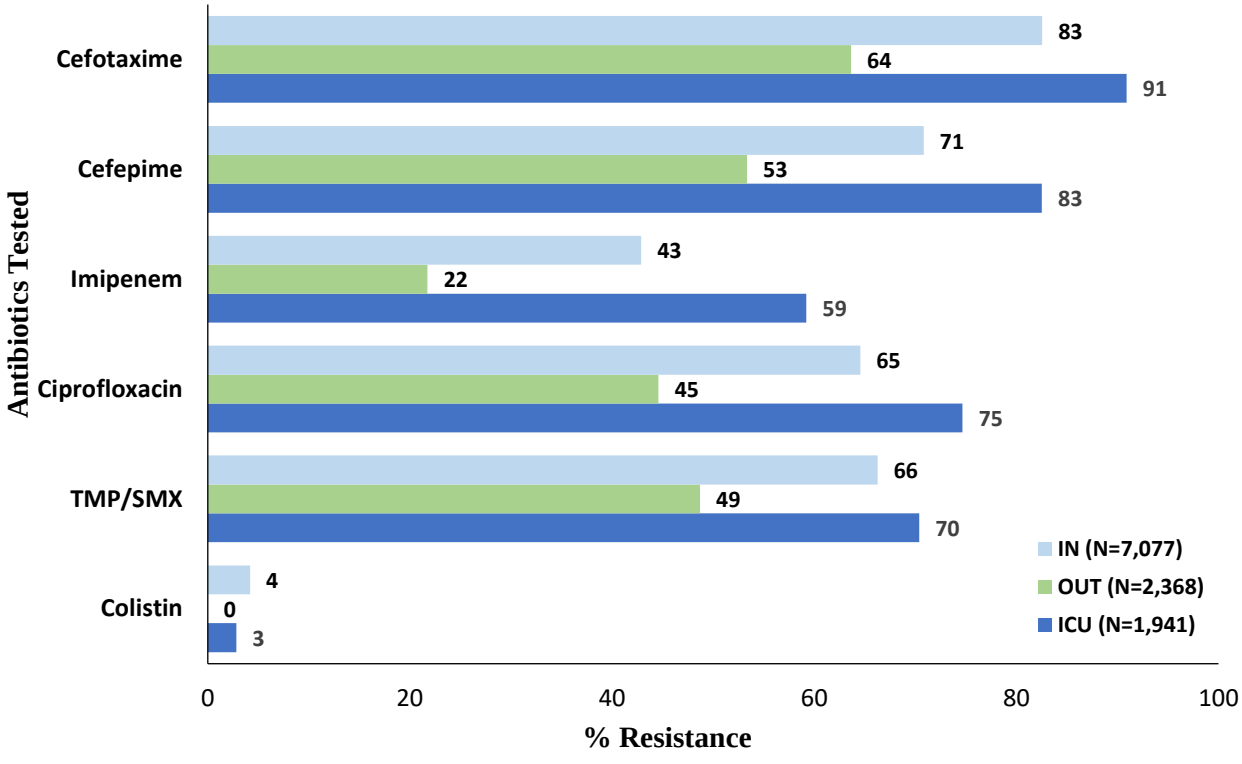



**Fig. 19** Resistance profile of *Klebsiella* species (N= 11,597) from blood, urine, PA & OSBF from different location types in healthcare facilities

Resistance to colistin in both *E.coli* and *Klebsiella* spp. is found to be higher in urine isolates than in isolates from blood and PA+OSBF, whereas resistance to 3rd generation cephalosporins and carbapenems is higher in blood and OSBF isolates than in urine isolates. (Fig. 20a). *Klebsiella* spp. isolates from blood culture shows higher resistance to all tested antibiotics than *E.coli* isolates (Fig. 20b).

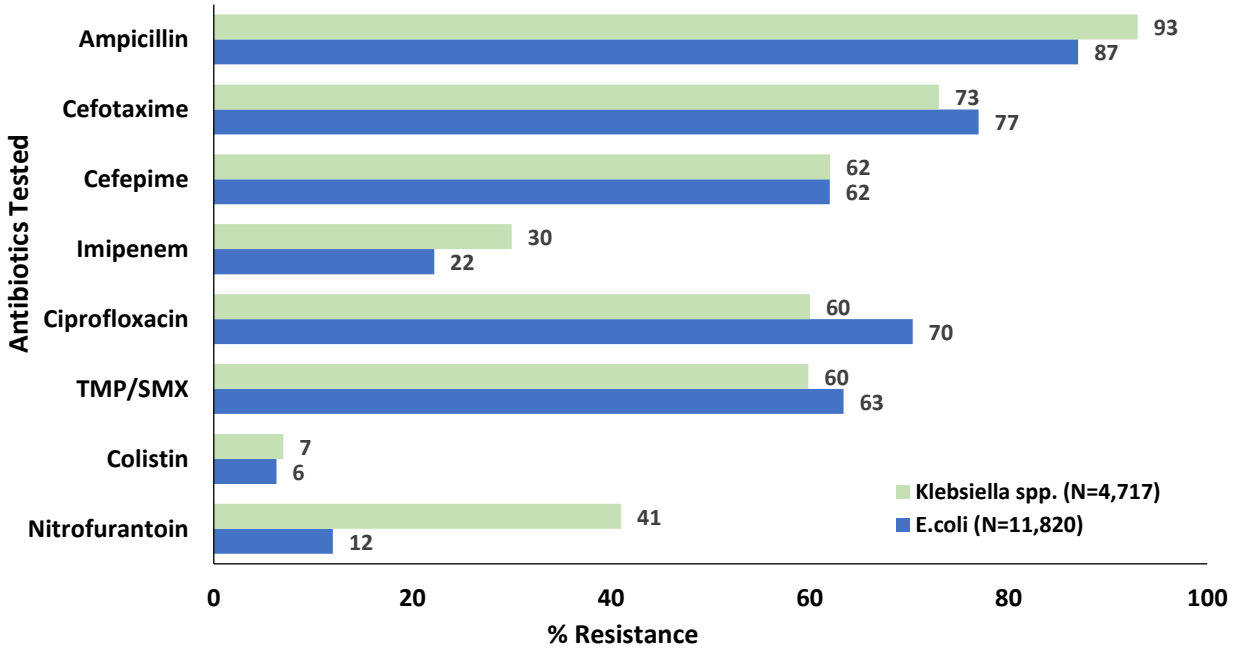



**Fig. 20a** Resistance Profile of *E. coli* and *Klebsiella* species isolated from urine specimens

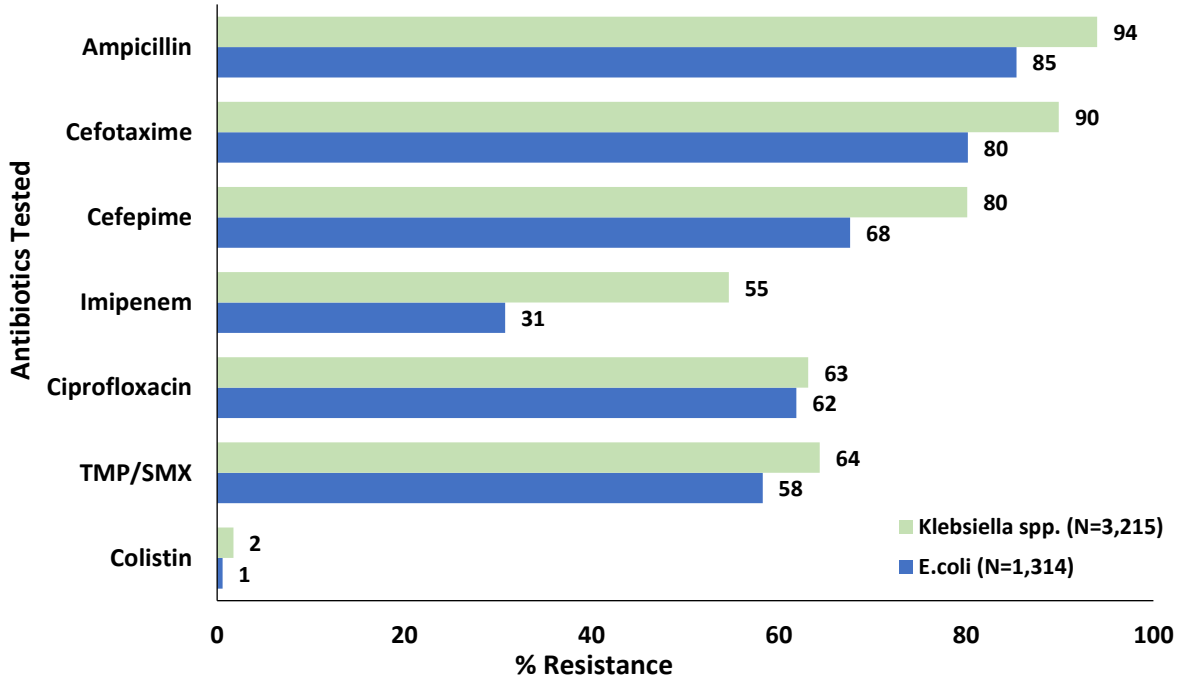



**Fig. 20b** Resistance profile of *E. coli* and *Klebsiella* species isolated from blood specimens

## *Salmonella* enterica *serotypes Typhi and Paratyphi*

During 2020, AST data of a total of 165 blood culture isolates was reported to NARS Net, while for the previous year AST data of 389 blood culture isolates of *Salmonella* Typhi was included in the annual report. 22% of *Salmonella enterica* serotype Typhi isolated from blood reported to NARS-Net were resistant to ciprofloxacin and 2% isolates were resistant to ceftriaxone (Table 10). Compared to the previous year, resistance to all antimicrobial tested in *Salmonella Typhi* isolates is less this year. Only one isolate of *Salmonella Typhi* has been reported from the stool specimen; hence is not included in the analysis. With 53% resistance to ciprofloxacin, the *Salmonella* Paratyphi AMR pattern is concerned.

**Table 10** Resistance profile of *Salmonella enterica* serotype Typhi and Paratyphi isolated from blood specimens (N= 169)

| Antibiotic tested | S. Typhi (N=152) | | S. Paratyphi (N=17) | |
|---|---|---|---|---|
| | Number Tested | %R | Number Tested | Number Resistant |
| Chloramphenicol | 94 | 7 | 7 | 0 |
| Azithromycin | 121 | 3 | 8 | 0 |
| TMP/SMX | 136 | 7 | 15 | 3 |
| Ciprofloxacin | 125 | 22 | 17 | 9 |
| Imipenem | 107 | 2 | 15 | 0 |
| Ceftriaxone | 123 | 2 | 12 | 2 |
| Ampicillin | 117 | 10 | 12 | 4 |

## ii. *Non-Fermenting Gram-Negative Bacilli*

Two important non-fermenting gram-negative bacilli (NFGNB) included in the priority pathogen list for AMR surveillance under NARS-Net are *Pseudomonas* spp. and *Acinetobacter* spp. Total of 11,566 NFGNB are reported from 10,010 unique patients. Among the NFGNB, *Pseudomonas* spp. is the commonest isolate 6,220 (11%), followed by *Acinetobacter* spp. 4,959 (9%) (Fig. 3).

### *Pseudomonas* species

Total 6,515 *Pseudomonas* spp. isolates are reported from 6,220 unique patients. *Pseudomonas* spp. has been isolated from 9% of ICU patients (Fig. 8). In previous year report, *Pseudomonas* spp. isolates showed lower resistance (31%) to piperacillin-tazobactam as compared to other antibiotics tested however this year resistance to piperacillin-tazobactam has increased to 42% which is at par with other antibiotics tested (Fig. 21). Among the isolates from ICU, highest resistance (60%) is observed to beta-lactam antibiotic ceftazidime while 4% resistance to colistin is observed (Fig. 22). Resistance to imipenem is 43% in ICU isolates, followed by 36% in in-patient isolates and 33% in outpatient isolates. In PA & OSBF highest resistance (56%) is observed to ceftazidime and lowest resistance of 8% to colistin is observed (Fig. 22). Isolates of *Pseudomonas* spp. from urine specimens showed higher resistance to colistin (10%) than those isolated from PA & OSBF (8%) and blood (0.5%) (Table 13).

**Table 11** Specimen wise resistance profile of *Pseudomonas* species (N = 6,220)

| Antibiotic tested | Blood (N=1,141) | | | PA + OSBF (N=3,101) | | | Urine (N=1,999) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R |
| Colistin | 189 | 1 | 0.5 | 370 | 28 | 8 | 84 | 8 | 10 |
| Gentamicin | 839 | 297 | 35 | 2,330 | 1,138 | 49 | 1,310 | 606 | 46 |
| Amikacin | 728 | 244 | 34 | 2,391 | 1,055 | 44 | 1,683 | 662 | 39 |
| Imipenem | 836 | 278 | 33 | 2,693 | 966 | 36 | 1,591 | 574 | 36 |
| Cefepime | 425 | 177 | 42 | 1,326 | 659 | 50 | 564 | 295 | 52 |
| Ceftazidime | 887 | 481 | 54 | 2,627 | 1,462 | 56 | 1,689 | 872 | 52 |
| Piperacillin/ Tazobactam | 851 | 325 | 38 | 2,615 | 1,119 | 43 | 1,562 | 662 | 42 |
| Ciprofloxacin | 743 | 307 | 41 | 2,483 | 1,348 | 54 | 1,615 | 888 | 55 |

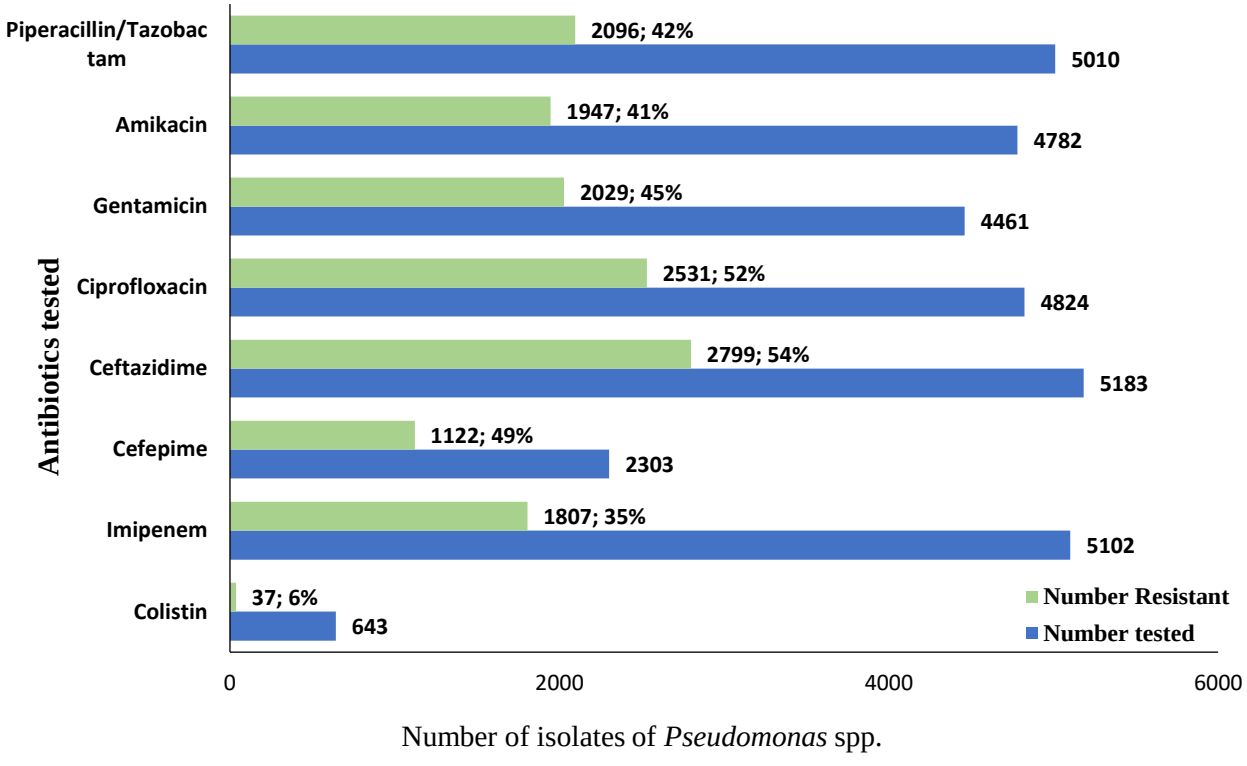



**Fig. 21** Resistance profile of *Pseudomonas* species (N= 6,220)

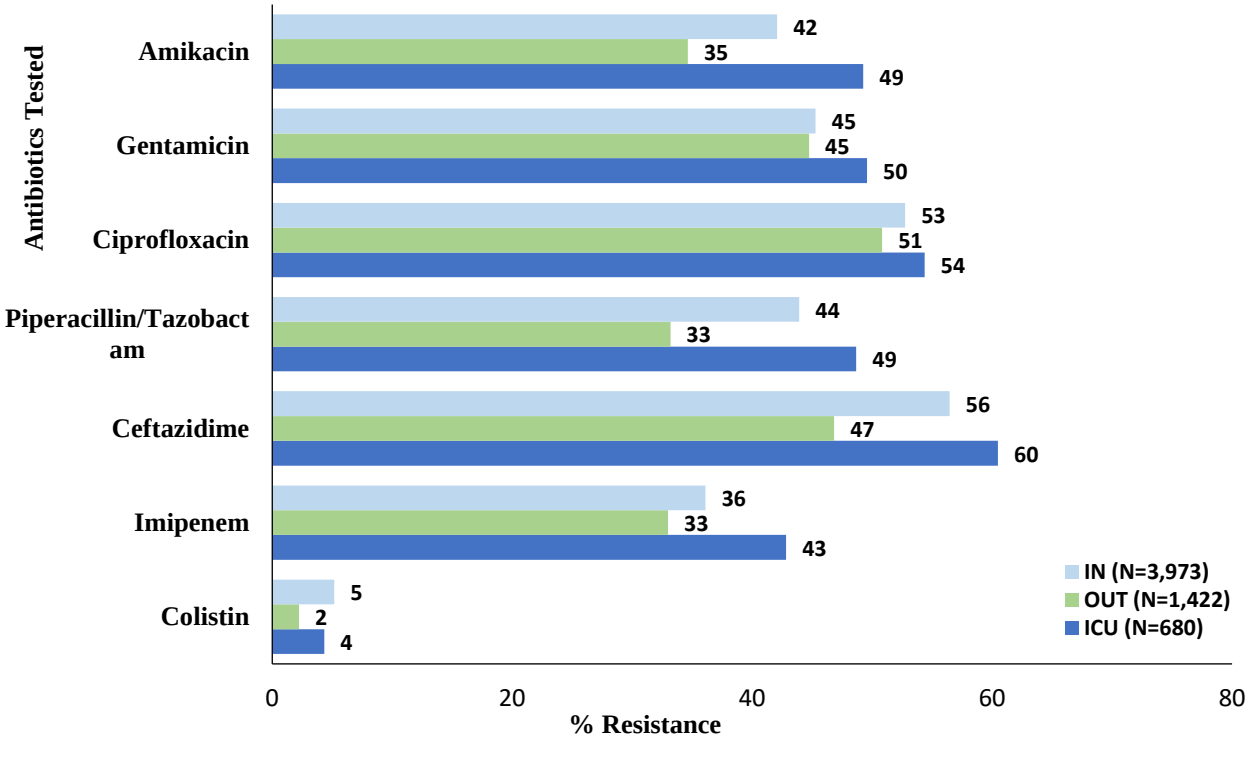



**Fig. 22** Resistance profile of *Pseudomonas* species isolated from blood, urine, PA+OSBF from different location types in healthcare facilities

## *Acinetobacter* species

Total 5,051 *Acinetobacter* spp. isolates are reported from 4,959 unique patients. *Acinetobacter* species constitutes 9% of the total isolates reported during 2020 (Fig. 3). The majority of *Acinetobacter* spp. are isolated from IPD patients (3,042), followed by ICU (1,311) & OPD (520) (Fig. 8). The *Acinetobacter* spp. isolates are more from blood (2,228) than from PA & OSBF (1,774) and urine (973) (Table 12).

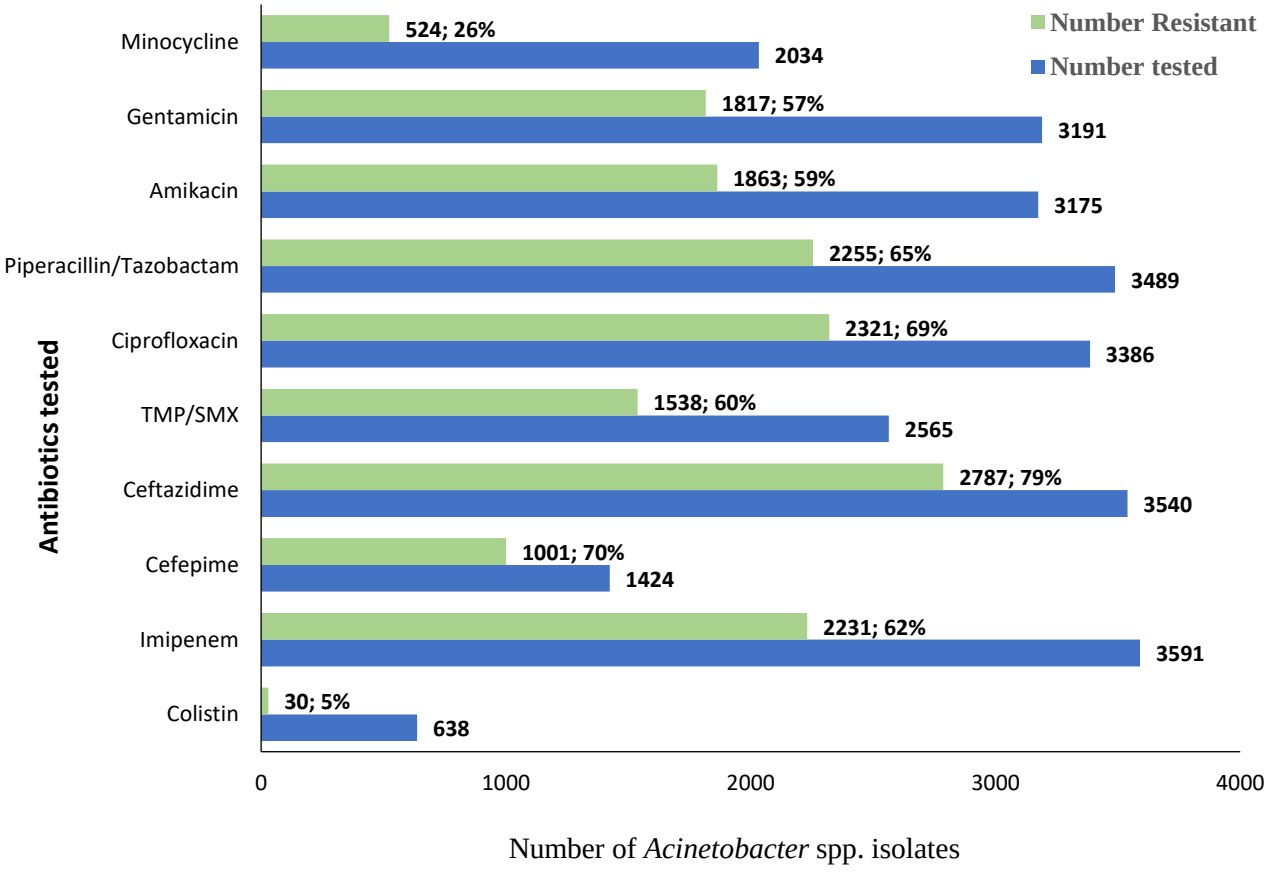



**Fig. 23** Resistance profile of *Acinetobacter* species (N= 4,959)

The highest number of *Acinetobacter* spp. isolates in this report are from blood 2,228 followed by PA & OSBF 1,774 and urine 973 (Table 12). Significantly higher resistance is observed in isolates from ICU: 82% to ceftazidime, 77% to ciprofloxacin, 75% to piperacillin/tazobactam and 73% to imipenem (Fig. 24). In blood culture isolates, highest resistance is reported to ceftazidime 78%; colistin resistance reported is 5% (Table 12).

**Table 12**. Specimen wise resistance profile of *Acinetobacter* species (N= 4,959)

| Antibiotic tested | Blood (N=2,228) | | | PA + OSBF (N=1,774) | | | Urine (N=973) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R | Number tested | Number Resistant | %R |
| Piperacillin/ Tazobactam | 1,417 | 890 | 63 | 1,431 | 1,067 | 75 | 656 | 310 | 47 |
| Ceftazidime | 1,480 | 1,150 | 78 | 1,444 | 1,246 | 86 | 629 | 404 | 64 |
| Cefepime | 755 | 510 | 68 | 548 | 427 | 78 | 124 | 67 | 54 |
| Imipenem | 1,473 | 945 | 64 | 1,432 | 1,012 | 71 | 697 | 282 | 40 |
| Amikacin | 1,281 | 732 | 57 | 1,280 | 875 | 68 | 627 | 268 | 43 |
| Gentamicin | 1,383 | 720 | 52 | 1,228 | 829 | 68 | 594 | 281 | 47 |
| Ciprofloxacin | 1,399 | 896 | 64 | 1,299 | 1,047 | 81 | 700 | 388 | 55 |
| TMP/SMX | 1,146 | 645 | 56 | 964 | 665 | 69 | 462 | 234 | 51 |
| Colistin | 364 | 18 | 5 | 226 | 7 | 3 | 48 | 5 | 10 |
| Minocycline | 923 | 224 | 24 | 691 | 172 | 25 | 427 | 129 | 30 |

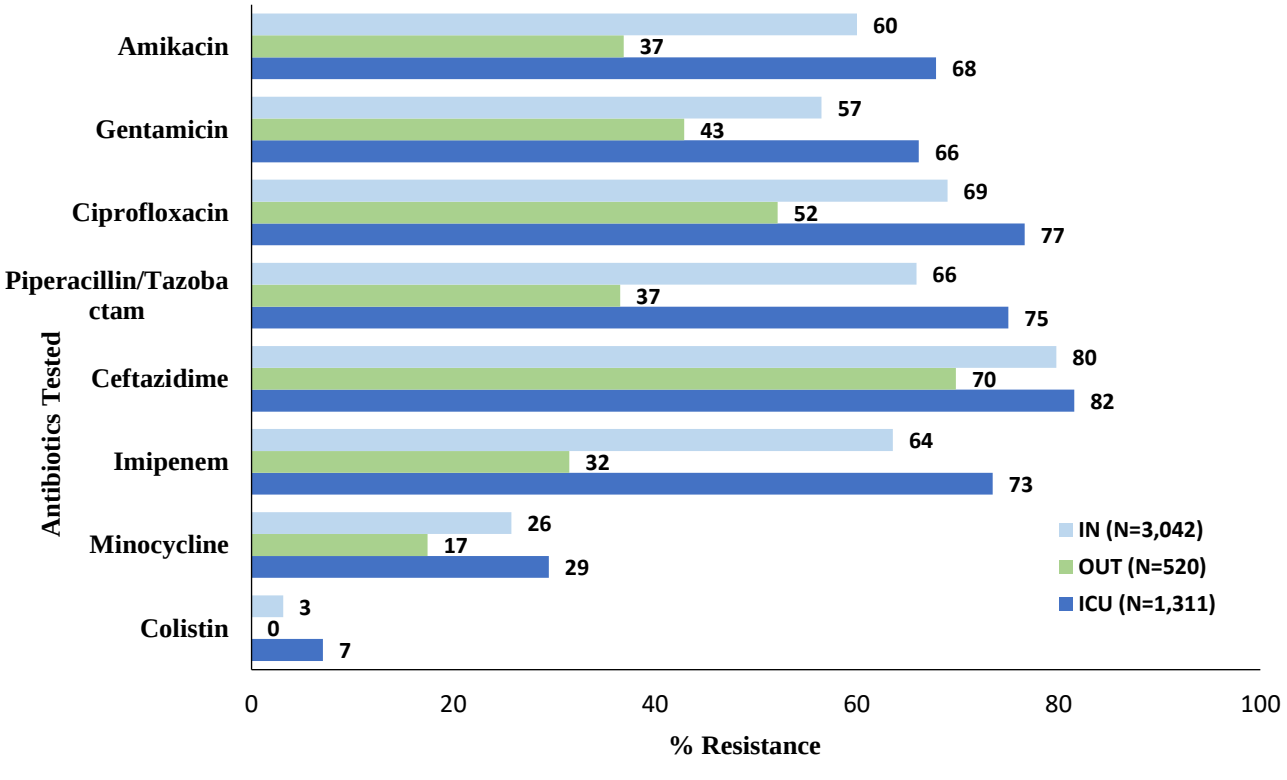



**Fig. 24** Resistance profile of *Acinetobacter* spp. isolated from blood, urine, PA+OSBF from different location types in healthcare facilities

Imipenem-resistance reported in *Acinetobacter* spp. during 2020 is high: 73% in ICU, 64% in IPD patients and 32% in OPD patients (Fig. 24). Minocycline is an alternate antimicrobial option to treat *Acinetobacter* infections. Monitoring its resistance profile is also essential for the treatment of such infections. Trend of imipenem and minocycline resistance in *Acinetobacter* spp. from 2017 to 2020 can be seen in Fig. 25.

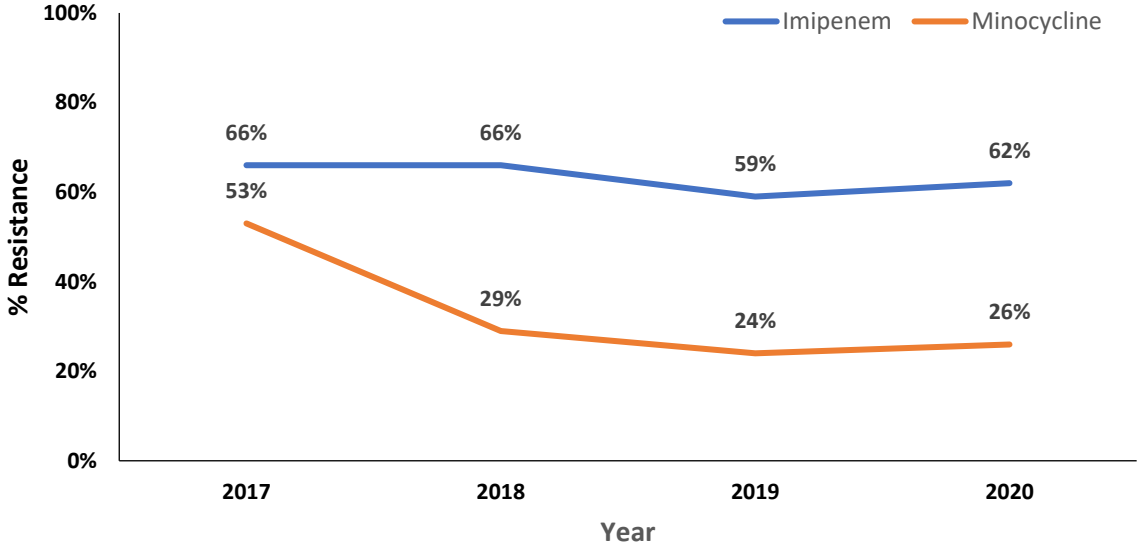



**Fig. 25** Trend of imipenem and minocycline resistance in *Acinetobacter* species (2017-2020)

# 6. Discussion

Antimicrobial resistance (AMR) is a global health challenge that threatens the achievement of Sustainable Development Goals (SDGs) related to health for all. WHO has declared AMR as one of the top 10 global public health threats. Under the National Programme on AMR Containment, NARS-Net annually generates the National AMR Surveillance report. NARS-Net activities include capacity building of a network of medical college laboratories to detect AMR surveillance. This network is being expanded in a phased manner to all states and UTs in the country. AMR surveillance under NARS-Net includes standardised collection, analysis and compilation of AMR data from the network sites. The compiled data is used to generate the annual National AMR surveillance report which is shared with stakeholders at the National and state level and is also made available in the public domain (on NCDC website). This network data is also submitted annually to WHO's Global AMR Surveillance System (GLASS).

This report for the year 2020 presents analysed data from 29 sentinel sites located in 24 states/UTs of India. Compared to the previous year's National AMR Surveillance Report which included 2019 data from 21 network sites, the number of sites submitting the AMR data during 2020 has increased to 29 network sites. However, during 2020 due to the COVID-19 pandemic, AST data submitted by the network sites is for lesser number of isolates as compared to the previous year. Quality of AMR surveillance data submitted by the sites has been ensured by continuous support in the form of trainings based on standard operating procedures for data management, antimicrobial susceptibility testing, internal quality control (IQC) and other technical guidelines developed by NCDC. The number of centres performing colistin BMD has increased compared to the previous year. During 2020, a virtual capacity-building program has been initiated to standardise bacteriology testing methods at the laboratories across the network using the ECHO platform. In addition, quarterly feedbacks on AMR data are provided to the network sites using a customised VBA tool (developed with support from CDC-India). Network laboratories have played an essential role in improving the patient demographic & AST data compliance. Most sites have also become stringent in conducting internal quality control of antibiotic discs as per recommendations under the programme. Certain limitations that could affect this data are lack of strict compliance to the internal quality control SoPs by some sites. Including data from greater number of centres and from all states and UTs would make the data more representative for the country.

*E. coli* is the most commonly reported pathogen (31%) in the AMR Surveillance data of 2020, similar to the previous three years report. Notably, *E. coli* isolates showed increased resistance to colistin this year (3.1%) compared to last year (0.5%), which may be attributed to greater number of sites reporting data of broth microdilution testing for colistin. Similar to the previous year reports, *E. coli is* the most frequently isolated pathogen from urine (39%) and *S. aureus* is the predominant pathogen isolated from both blood (31%) and PA & OSBF (28%). Among outpatients (41%) and inpatients (29%) *E. coli* is the commonest pathogen isolated, whereas *Klebsiella* spp. is the predominant pathogen isolated (26%) in ICU settings.

Methicillin-resistant *S. aureus* (MRSA) isolates have decreased to 57% this year compared to the previous year's 66%. This year's data revealed linezolid resistance in 1% *S. aureus* isolates. Data of vancomycin resistance in *S. aureus* could not be included in this report as no sites reported BMD testing data. Among 10% of Enterococci isolated from blood and urine vancomycin resistance is observed.

Presently resistance to last-resort antibiotics is increasing compared to that very few newer drugs are in the pipeline. Strengthening local infection prevention and antimicrobial stewardship practices at healthcare facilities in the country and initiating multisectoral action as stated in the National action plan on AMR is the need of the hour.