Ministry of Health
and Family Welfare
Government of India

Annual Report

National Antimicrobial Surveillance Network (NARS-Net)

Reporting period:
1 January – 31 December 2022

National Programme on AMR Containment, National Centre for Disease Control (NCDC)
Directorate General of Health services
Ministry of Health & Family Welfare
Government of India

July 2023

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Acronyms

AMR	Antimicrobial Resistance
Amox-Clav	Amoxicillin/Clavulanic acid
AST	Antimicrobial Susceptibility Testing
BMD	Broth Microdilution
CBDDR	Centre for Bacterial Diseases and Drug Resistance
CLSI	Clinical & Laboratory Standards Institute
CSV	Comma Separated Value
ECHO	Extension for Community Healthcare Outcomes
EQAS	External Quality Assessment Scheme
GLASS	Global Antimicrobial Resistance and Use Surveillance System
IPD	Inpatient Department
ICU	Intensive Care Unit
ID	Identification
IQC	Internal Quality Control
LIMS	Laboratory Information Management System
MRSA	Methicillin-Resistant Staphylococcus aureus
NARS-Net	National Antimicrobial Resistance Surveillance Network
NFGNB	Non-fermenting Gram-negative bacilli
NCDC	National Centre for Disease Control
NRL	National Reference Laboratory
OPD	Outpatient Department
OSBF	Other Sterile Body Fluids
PA	Pus Aspirate
R I S	Resistant Intermediate Sensitive
TMP-SMX	Trimethoprim-Sulfamethoxazole
S.O.P.	Standard Operating Procedure
VBA	Visual Basic Application
VRE	Vancomycin-Resistant Enterococcus species
WHO	World Health Organization

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I. Executive Summary

Antimicrobial resistance (AMR) is a very important global health issue and has been recognized as one of the top ten public health threats by the World Health Organization. AMR poses significant challenges across sectors and necessitates strengthening global, national, and local AMR surveillance efforts. Effective surveillance through collecting and analyzing AMR data is crucial for monitoring antibiotic resistance trends and enabling targeted public health interventions.

Under the National Programme on AMR Containment, the National Antimicrobial Resistance Network (NARS-Net) coordinated by the National Centre for Disease Control (NCDC) generates the annual National AMR surveillance report. NARS-Net is being expanded to all states and Union Territories in a phased manner, ensuring the generation of geographically representative data. The surveillance activities of NARS-Net involve the standardized collection, analysis, and compilation of AMR data from all network sites through WHONET, which is an open source software for microbiology data management.

The aggregated data is used to generate the annual National AMR surveillance report which is shared with national and state stakeholders and is available in public domain on the NCDC website. It is important to note that for vancomycin-resistant *S. aureus* and colistin-resistant gram-negative bacteria, only isolates with confirmed identification and antimicrobial susceptibility testing (AST) at the AMR-national reference laboratory (NRL) located at Centre for Bacterial Disease and Drug Resistance (CBDDR), National Centre for Disease Control (NCDC), New Delhi are included in the data. The network data is also submitted annually to the World Health Organization's Global AMR Surveillance and Use System (WHO-GLASS) since 2018 by the National AMR Surveillance Coordinating Centre for India at NCDC.

Data Reporting and Quality Assurance

The current report covers the data reporting period from 01 January 2022 to 31 December 2022 and includes analyzed data from 36 sentinel sites in 27 States/ Union Territories. To ensure the quality of AMR surveillance data submitted by the sites, continuous capacity-building trainings are conducted based on standard operating procedures for antimicrobial susceptibility testing, internal quality control (IQC), data management, and other technical guidelines developed by NCDC based on International Guidelines and standards including

Clinical Laboratory Standard Institute Guidelines (CLSI). The number of sentinel sites performing colistin broth microdilution (BMD) and vancomycin BMD has gradually increased under NARS-Net. The virtual capacity-building program initiated through the ECHO platform in 2020 and the continuous hands on training on WHONET has been instrumental in standardizing bacteriology testing methods and report generation across the network sites. Furthermore, quarterly feedback on AMR data is provided to the network sites which has played a crucial role in improving compliance to demographic details and AST data standards defined under the programme. All network sites are enrolled in External Quality Assessment Scheme (EQAS) programs and are implementing internal quality control measures for antibiotic discs and culture media.

AMR Surveillance Findings

Over the past four years, there has been a gradual increase in the number of reported isolates, rising from 25,833 in 2017 to 1,19,686 during the current data reporting period. Consistent with the previous five years, *Escherichia coli* (*E. coli*) remains the most commonly isolated pathogen, accounting for 33% of the AMR surveillance data in 2022. Majority of the reported isolates were from urine samples (43%) and among urinary isolates *E. coli* was the predominantly isolated pathogen. Among the isolates reported from pus aspirates (28% of all specimens), *S. aureus* was the most common aligning with the previous year's findings. In terms of location, over half of the priority pathogens (56%) were isolated from in-patient wards, where *E. coli* was the most frequently isolated pathogen from in-patient (31%), outpatient (42%), and emergency settings (32%), consistent with the previous year's report. A significant decrease in the proportion of Methicillin-resistant *S. aureus* (MRSA) in blood was observed in the current data (59%) compared to previous years since 2018. Conversely, there was an increase in the proportion of Vancomycin-resistant *Enterococcus* spp. (VRE) isolated from blood cultures (13%) in the year 2022.

The trend analysis for Extended-spectrum beta-lactamase (ESBL) producing blood isolates of *E. coli* revealed a significant decrease in the proportion of ESBL-producing *E. coli* isolates from 86% in 2018 to 76% in 2022. This reduction in resistance may be attributed to the stringent internal quality control measures implemented for antibiotic discs and the increased number of sentinel sites in the NARS-Net over the years. Approximately 35% of

E. coli and 47% of *Klebsiella* spp. were resistant to at least one of the carbapenems, similar to the previous year's report (33% and 50%, respectively).

The data mentioned in this report is limited to Government hospitals, mostly medical college hospitals which provide tertiary care as part of public healthcare system in India. Also, most of the data is from admitted patients due to limited utilization of the laboratory services for patients attending outpatient departments.

Increasing resistance to reserve group[1] of antibiotics poses a serious threat since no new drugs are in the pipeline. Combating AMR necessitates urgent, multisectoral, and multipronged strategies focused on strengthening local infection prevention, promoting judicious use of antibiotics through strong antimicrobial stewardship practices in healthcare facilities and addressing the drivers of AMR.

Conclusion:

The annual National AMR Surveillance Report generated by NARS-Net provides critical insights into India's evolving antimicrobial resistance trends. Expanding the network to all states and Union Territories, along with continuous capacity building and quality assurance efforts, has improved the coverage and reliability of the surveillance data. It is essential to leverage these findings to inform evidence-based interventions, policies, and programs that will mitigate the threat of AMR and preserve the effectiveness of antibiotics for the treatment of infectious diseases in the country.

[1] https://adoptaware.org/

II. National AMR Surveillance Network

Antimicrobial resistance (AMR) has emerged as a major public health threat requiring urgent prevention and control measures. Government of India has taken several initiatives to combat this major public health challenge. One of the key initiative is the launch of "National Programme on Antimicrobial Resistance (AMR) Containment" in 2013, during the 12th five-year plan (2012-2017). This programme is being coordinated by National Centre for Disease Control (NCDC), Delhi. The objective of the programme is to build capacity of medical colleges and other large hospitals to generate quality AMR surveillance data thereby monitor trends of AMR in the country. Under the programme, a network of laboratories called National AMR Surveillance Laboratory network (NARS-Net) has been established. NARS-Net started the journey with eight medical college laboratories through a sentinel surveillance approach. The sentinel surveillance network sites have been expanded in a phased manner to include 40 laboratories in 31 states/UTs (as of March 2023)[2] and the National reference laboratory for bacterial pathogens at NCDC. India also launched its National Action Plan on AMR (NAP-AMR) in April 2017 with 6 strategic priorities namely improve awareness and understanding of AMR through effective communication, education and training, strengthen knowledge and evidence through surveillance, reduce the incidence of infection through effective infection prevention and control, Optimize the use of antimicrobial agents in health, animals and food, Promote investments for AMR activities, research and innovations and strengthen India's commitment and collaborations on AMR at international, national and sub-national levels. In 2017 NCDC was also designated by MoHFW as the National Coordinating Centre for WHO-Global Antimicrobial Resistance Surveillance and Use System (GLASS). Antimicrobial Resistance data of selected WHO priority pathogens generated by healthcare laboratories which are part of the AMR surveillance programs in India is collated and submitted to WHO-GLASS since 2018.

The NARS-Net sentinel sites conduct laboratory-based AMR surveillance of seven priority bacterial pathogens namely

1. *Staphylococcus aureus*
2. *Enterococcus* species

[2] National Programme on AMR Containment :: National Centre for Disease Control (NCDC) (mohfw.gov.in)

3. *Escherichia coli*
4. *Klebsiella* species
5. *Pseudomonas* species
6. *Acinetobacter* species
7. *Salmonella enterica* serotype Typhi and Paratyphi

To ensure that the data is from clinically significant isolates, the clinical specimens currently included in AMR Surveillance are-

Clinical Specimen	Laboratory case-definition	Priority pathogens under AMR Surveillance
Blood		*Enterococcus* species *Staphylococcus aureus* *Escherichia coli* *Klebsiella* species *Acinetobacter* species *Pseudomonas* species *Salmonella enterica* serovar Typhi *Salmonella enterica* serovar Paratyphi
Urine	Clinically significant bacteriuria	*Enterococcus* species *Escherichia coli* *Klebsiella* species *Acinetobacter* species *Pseudomonas* species
Pus Aspirate	Growth of pathogenic bacteria from aspirated purulent material from a closed infected site	*Enterococcus* species *Staphylococcus aureus* *Escherichia coli* *Klebsiella* species *Acinetobacter* species *Pseudomonas* species
Other sterile body fluids	Growth of pathogenic bacteria from a sterile body fluid specimen	*Enterococcus* species *Staphylococcus aureus* *Escherichia coli* *Klebsiella* species *Acinetobacter* species *Pseudomonas* species
Stool	Isolation of pathogen from stool	*Salmonella enterica* serovar Typhi *Salmonella enterica* serovar Paratyphi

The scope of surveillance has been expanded to include additional bacterial pathogens starting from April 2023 after the release of the revised AMR surveillance SOP.

All the participating network sites report AMR data of seven priority pathogens from the listed specimen types to NCDC. The network sites are mandated to have internal quality control practices

in place at their laboratories and participate in External Quality Assessment Scheme (EQAS) for bacteriology. Each quarter, the network sites send a defined number of isolates for confirmation of identification and AST as apart of EQAS conducted by the NRL at Centre for Bacterial Diseases and Drug Resistance (CBDDR), NCDC. Apart from reporting the AMR data the sites are also mandated to share all emerging AMR alert isolates for confirmation to NRL at NCDC.

NCDC provides continuous technical support to each sentinel surveillance network laboratory to ensure proper specimen collection, bacterial culture, identification and antimicrobial susceptibility testing (AST), quality management systems and data management. This includes virtual and in person hands-on trainings on WHONET data management software & laboratory techniques. Onsite hand holding visits and trainings were organized for the sites to strengthen bacteriology laboratory capacity, improving the quality of culture, ID and AST practices. WHONET is a free microbiology data entry and analysis software used under the programme to standardize AMR surveillance data flow from network sites to NCDC. In addition, hands-on trainings and tools were provided for developing facility level antibiograms for guiding the development of antibiotic policies.

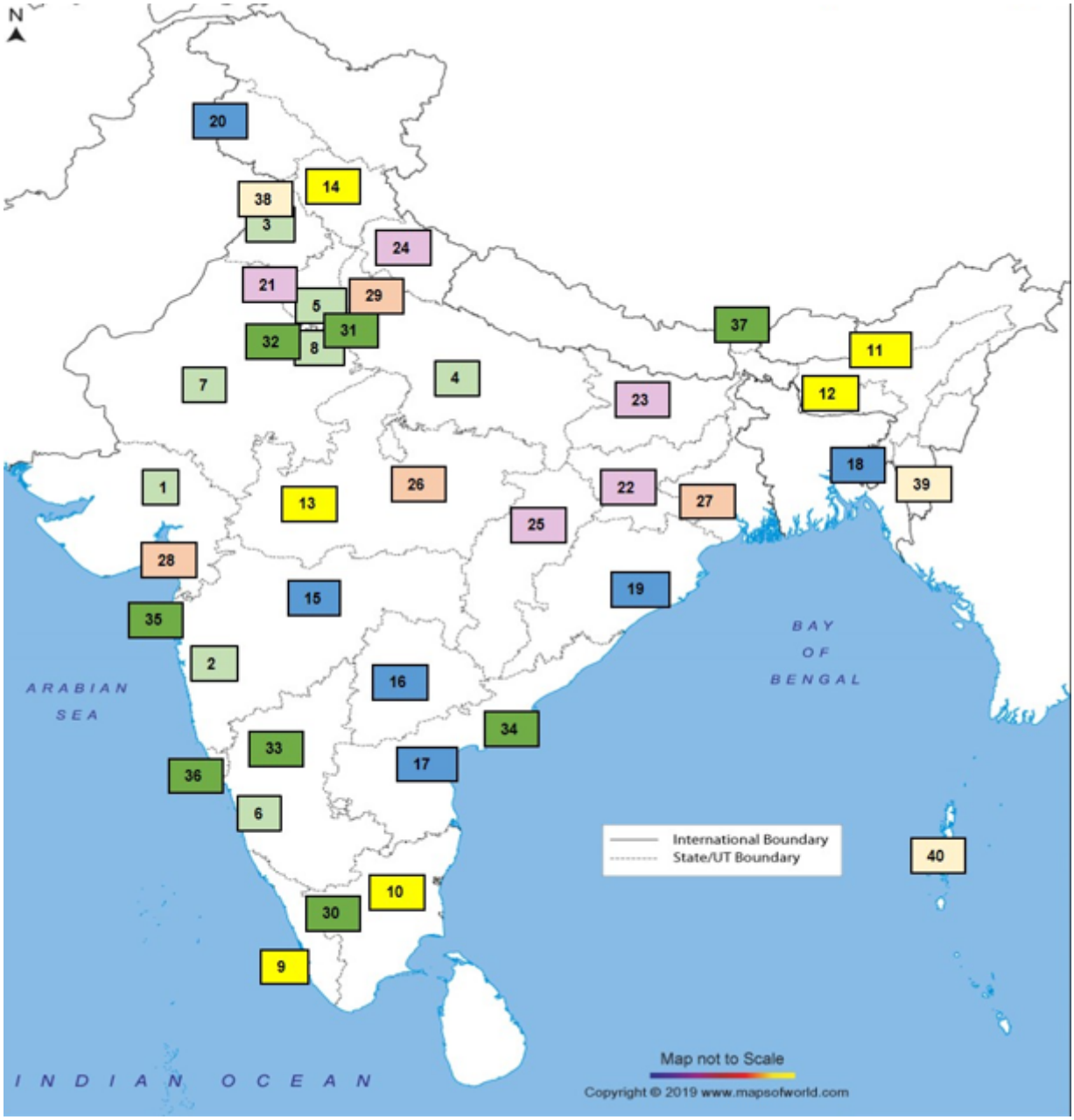


Figure 1- National AMR Surveillance Network laboratories under NARS-Net as of March 2023[3]

[3] National Programme on AMR Containment :: National Centre for Disease Control (NCDC) (mohfw.gov.in)

III. Data Collection and Analysis

The WHONET 2022, an open-source offline microbiology data management desktop application, was used to enter, collate and analyze routine antimicrobial susceptibility data generated by manual testing methods and automated systems at the laboratories. The classification of the isolates as susceptible, intermediate, or resistant is based on the Clinical & Laboratory Standards Institute (CLSI) guidelines. Total 1,28,529 priority pathogen demographical information and antimicrobial susceptibility data have been reported from 36 sites under NARS-Net (List at Annexure-1).

The sentinel sites submitted their data quarterly after validation by the respective AMR nodal officers at the sites.

The network sites submit the data within 15 days after each quarter:

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

The site's quarterly data is validated, checked for quality, and feedback for each quarter is submitted to the network site regarding the completeness of data fields and compliance to the AMR Surveillance panel of antibiotics. In addition to AMR data, a defined number of isolates are submitted as a part of the External Quality Assessment Scheme (EQAS) to NRL at NCDC. The sites must submit EQAS isolates to National Reference Laboratory (NRL), NCDC every quarter. The NRL at NCDC performs identification and susceptibility testing by strictly following the standard protocols; thus, after confirmation, results are returned to the sites. Antibiotic-resistant alert isolates of public health concerns were submitted to NCDC with a duly filled alert form for confirmation.

The annual report covers the AMR data from January 2022 to December 2022. The participating 36 sentinel surveillance sites are distributed nationwide, representing all regional antimicrobial susceptibility patterns. Sites perform antimicrobial susceptibility testing by disk diffusion, broth microdilution, agar dilution, and automated antimicrobial susceptibility testing systems.

While generating a single file from all the cumulative AMR data files, duplicate findings for the same patient have been excluded from the source database files. For analysis, from each patient,

only the first isolate of a given species isolated during the investigated time interval was included, regardless of its susceptibility profile[4]. For example, if two blood cultures from the same patient yielded growth of *E. coli*, only the first has been included in the data; if the growth of *E. coli* is detected in one culture and of *K. pneumoniae* in the other, both results are considered. If there is growth of *E. coli* in one blood culture and in one urinary culture from the same patient, both specimen types have been included.

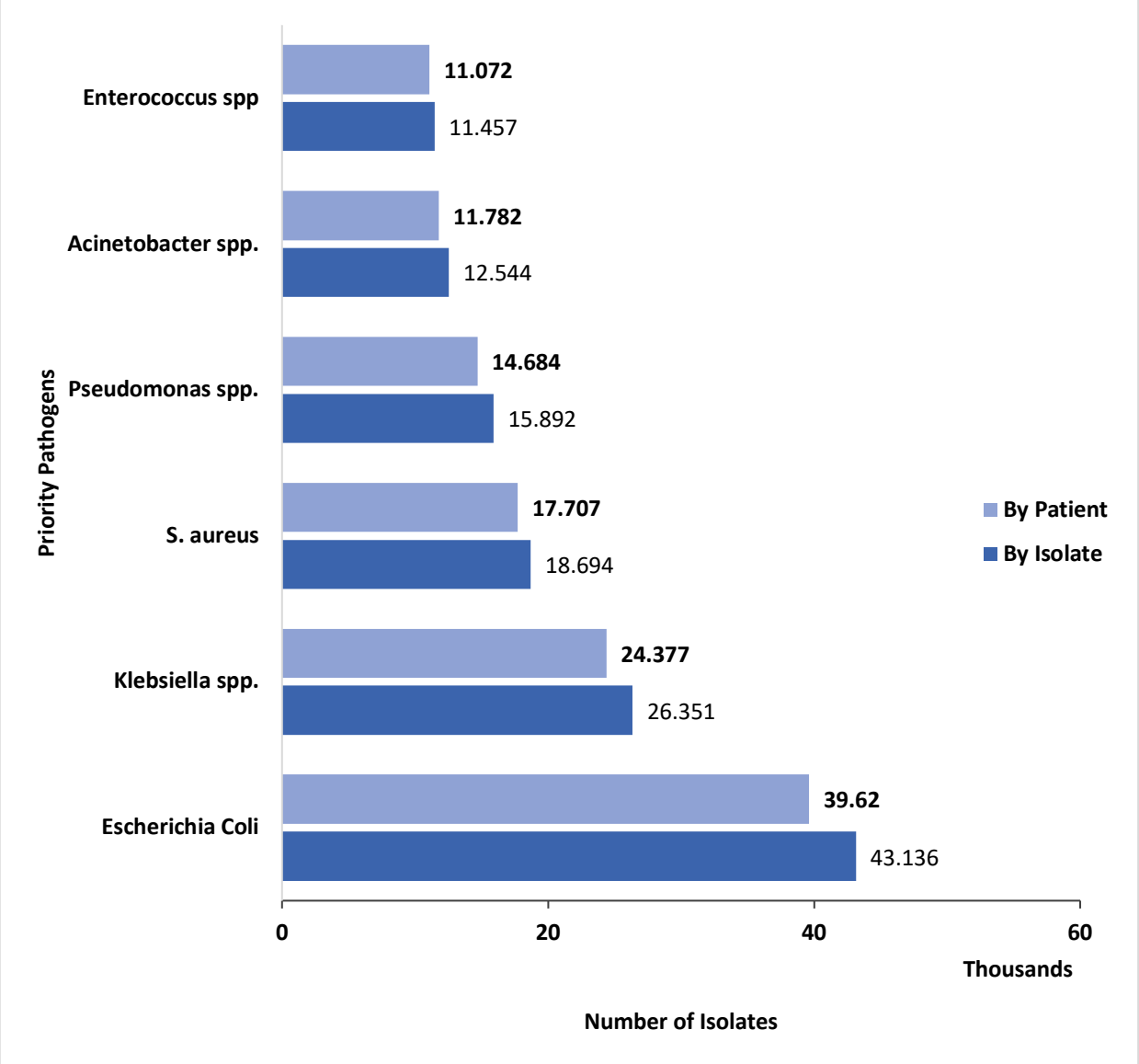


Figure 2- Distribution of priority pathogen isolates and Unique patient isolates

[4] National Programme on AMR Containment :: National Centre for Disease Control (NCDC) (mohfw.gov.in)

Priority Pathogens and Specimens under Surveillance in NARS-Net

The AMR data collected under the National Programme on AMR Containment from January 2022 to December 2022 from 36 medical colleges from 27 states/UTs includes seven priority pathogens and five clinical specimen types [Table 1].

Table 1- Priority Pathogens and specimens included under NARS-Net

Specimen	*S. aureus*	*Enterococcus* spp.	*Klebsiella* spp.	*Escherichia coli*	*Acinetobacter* spp.	*Pseudomonas* spp.	*Salmonella Typhi / Paratyphi*
Blood	✓	✓	✓	✓	✓	✓	✓
Urine		✓	✓	✓	✓	✓	
Pus Aspirate	✓	✓	✓	✓	✓	✓	
Other Sterile body fluids*	✓	✓	✓	✓	✓	✓	
Stool							✓

* OBSF- Include abdominal fluid, amniotic fluid, bile, cerebrospinal fluid, cyst, endocardium, hip fluid, joint fluid, knee fluid, lymph node, semen, broncho-alveolar lavage, spleen, pleural fluid, pericardial fluid, bone marrow, Bartholin's cyst, fluid, gastric fluid, gall bladder, breast milk and prostatic fluid

Age and Gender distribution of reported AMR data

The AST data was reported almost equally from male and female patients. As per the age category, almost one third of unique patients are in age group of 36-60 years, whereas the lowest number of isolates was reported from patients under five years of age. About 66 % of AST data was reported from the productive age group of 15-64.

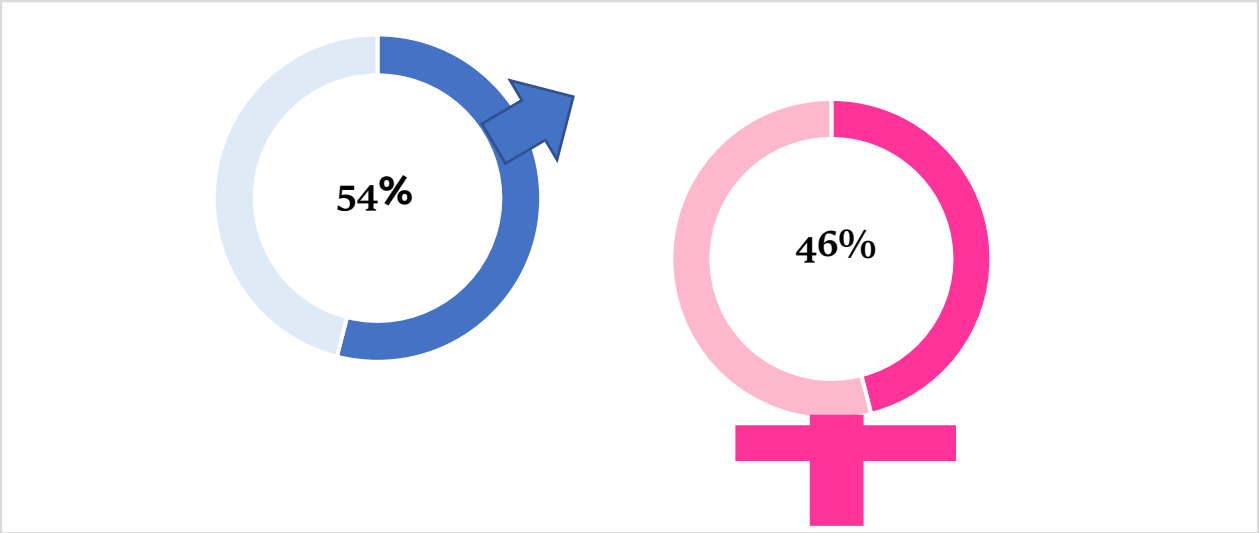


Figure 3 - Distribution of priority pathogen isolates by gender (N=1,19,553)

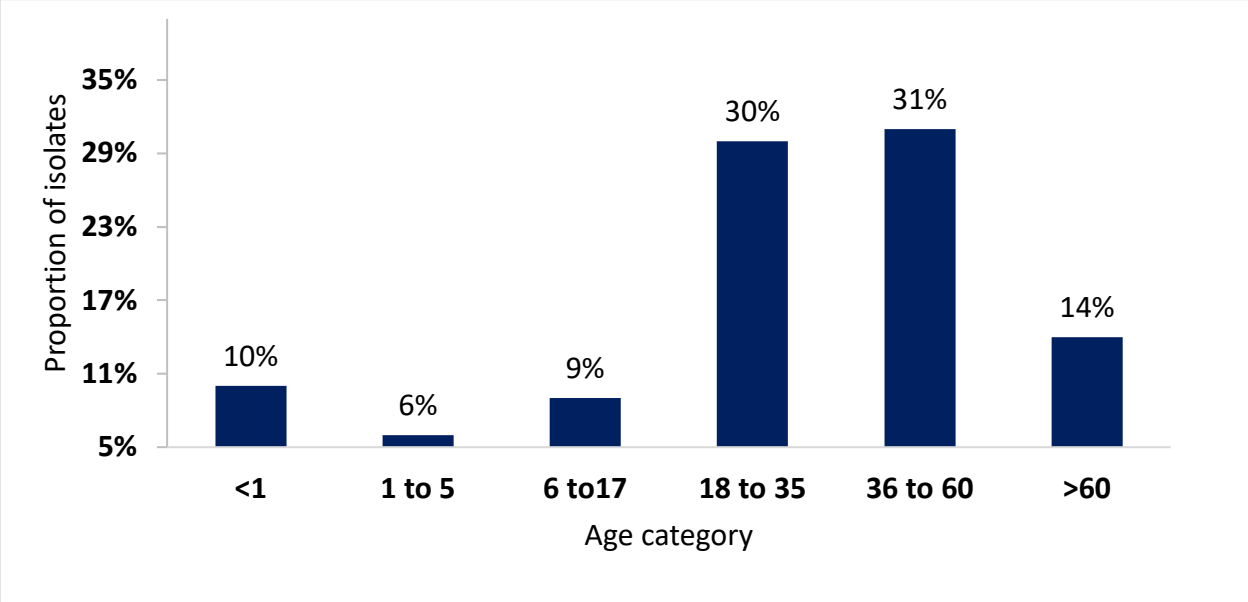


Figure 4 - Distribution of priority pathogen isolates by age category (N=1,16,100)

Table 2: Distribution of isolates based on specimen type (N=1,19,686)

Specimen Type	Number of isolates	(%)
Urine	51632	(43)
Blood	23244	(19)
Pus Aspirate	38083	(32)
Other sterile body fluids	6717	(6)
Stool	10	(0.01)
Total	1,19,686	(100)

In the AMR surveillance data for the year 2022, the most commonly isolated priority pathogen was *E. coli* (33%), which is similar to the previous year's data, followed by *Klebsiella* species (20%), *S. aureus* (15%), *Pseudomonas* species (12%), *Acinetobacter* species (10%) *Enterococcus* species (9%) and *Salmonella enterica* serovar Typhi and Paratyphi (0.4 %).

The specimen type from where most isolates have been reported in the current data was urine (43%). Like the previous years, *E. coli* remained the most commonly isolated pathogen from urinary samples. Among the blood and pus aspirate specimens, the most common priority pathogen isolated was *S. aureus* (27% & 28% respectively). *Salmonella enterica* serovar Typhi and Paratyphi (2%) were the least commonly isolated pathogen from blood among all priority pathogens reported under NARS-Net. *E. coli* (23%) and *Klebsiella* spp. (21%) were the most commonly isolated pathogens from other sterile body fluids*

Table 3- Distribution of priority pathogens by specimen type (N= 1,19,686)

Priority Pathogen	Blood		Pus aspirate		OSBF		Urine		Stool		Total	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Escherichia Coli	2496	(11)	8297	(22)	1548	(23)	27279	(53)	x		39620	(33)
Klebsiella spp.	4639	(20)	7592	(20)	1380	(21)	10766	(21)	x		24377	(20)
Salmonella Typhi and Paratyphi	434	(2)	x		x		x		10		444	(0.4)
Pseudomonas spp.	2457	(11)	6663	(17)	1181	(18)	4383	(8)	x		14684	(12)
Acinetobacter spp.	4820	(21)	3586	(9)	1285	(19)	2091	(4)	x		11782	(10)
S. aureus	6256	(27)	10695	(28)	756	(11)	x		x		17707	(15)
Enterococcus spp.	2142	(9)	1250	(3)	567	(8)	7113	(14)	x		11072	(9)
Total	23244	(100)	38083	(100)	6717	(100)	51632	(100)	10		119686	(100)

x - Specimen type not included under the programme

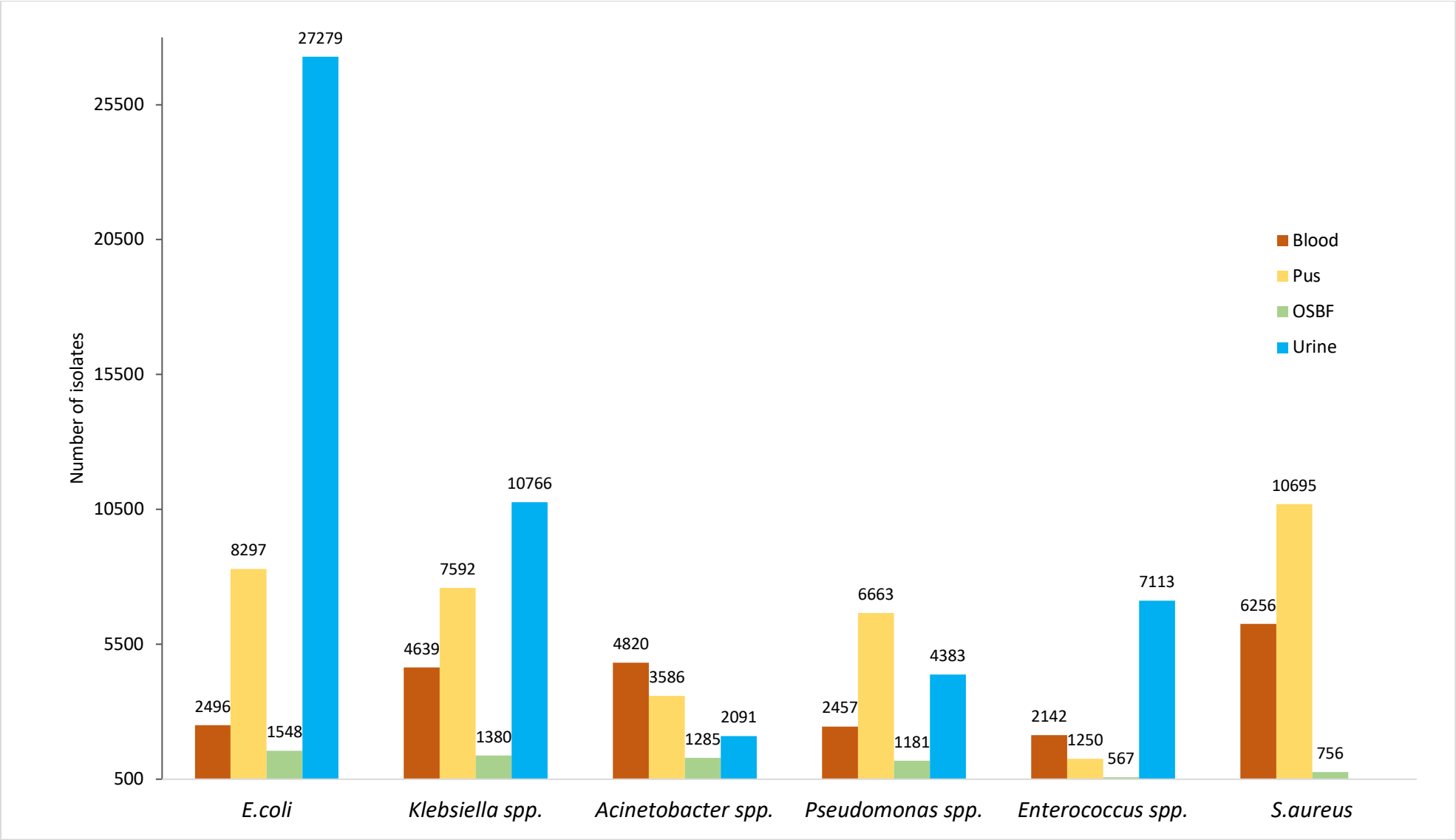
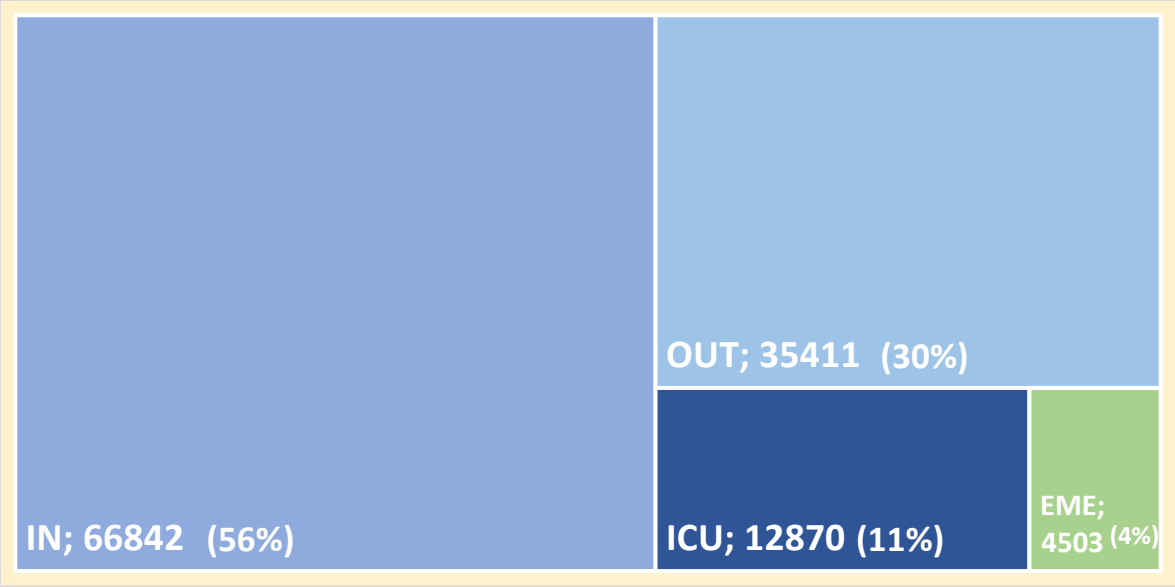


Figure 5: Distribution of priority pathogen isolates by specimen type (N=1,19,686)



IN – Inpatient; OUT–Outpatient; ICU –Intensive care; EME –Emergency

Figure 6- Distribution of priority pathogen isolates by location type (N=1,19,626)

In the 2022 AMR surveillance data, majority of the isolates were from patients admitted in hospital wards (IPD- 56%) whereas the least number of isolates belonged to patients from the Emergency department (4%). Almost a third of the isolates (30%) were from patients visiting the outpatient clinics. About 11% of the priority pathogens were isolated from Intensive care units.

Table 4- Distribution of priority pathogen isolates by location type (N=1,19,626)

Priority Pathogen	Inpatient (N=66842)		Outpatient (N=35411)		I.C.U. (N=12870)		Emergency (N=4503)	
	N	(%)	N	(%)	N	(%)	N	(%)
Escherichia Coli	2068	(31)	15034	(42)	2465	(19)	1422	(32)
Klebsiella spp.	14329	(21)	6289	(18)	3010	(23)	735	(16)
Salmonella Typhi and Paratyphi	274	(0.4)	83	(0.2)	63	(0.5)	24	(0.5)
Pseudomonas spp.	7986	(12)	4700	(13)	1583	(12)	413	(9)
Acinetobacter spp.	7162	(11)	1729	(5)	2447	(19)	440	(10)
S. aureus	10332	(15)	4392	(12)	1835	(14)	1136	(25)
Enterococcus spp	6082	(9)	3184	(9)	1467	(11)	333	(7)

Amongst the inpatients, the most commonly isolated priority pathogen was *Escherichia coli* (31%) followed by *Klebsiella* spp. (21%), however an reverse scenario was seen in Intensive care units wherein *Klebsiella* spp. (23%) was the most commonly isolated pathogen followed by *Escherichia coli* and *Acinetobacter* spp. (19% each). *Escherichia coli* was also the most commonly isolated pathogen from Outpatient clinics (42%) and emergency departments (32%) whereas the least commonly isolated pathogen amongst all of the location types was *Salmonella* Typhi and Paratyphi.

IV. AMR profile of priority pathogens

A. Gram Positive Cocci

The AMR surveillance under NARS-Net covers the two most commonly isolated gram-positive bacterial human pathogens i.e., *Staphylococcus aureus* and *Enterococcus* species. The AST data of 30,151 Gram positive cocci were submitted to NCDC, of which 28,779 isolates were from unique patients.

1. Staphylococcus aureus

Staphylococcus aureus constituted an overall 15% among the priority pathogen isolates (Table. 3). During the 2022 reporting period, a total of 18,694 *S. aureus* isolate AST data was submitted to NCDC of which 17,707 isolates were from unique patients. AST data analysis of 17,707 isolates indicates a significant contribution of *S. aureus* in bacteremia/septicemia and other systemic infections as the isolation rate from blood, aspirated pus, and sterile body fluids was 27%, 28%, and 11%, respectively.

Almost two-thirds (59%) of *S. aureus* isolates from blood were resistant to cefoxitin (a surrogate marker for mecA-mediated oxacillin resistance or MRSA) meanwhile, the resistance to cefoxitin in *S. aureus* from pus aspirates and other sterile body fluids was lower in comparison to the blood isolates (Table 5).

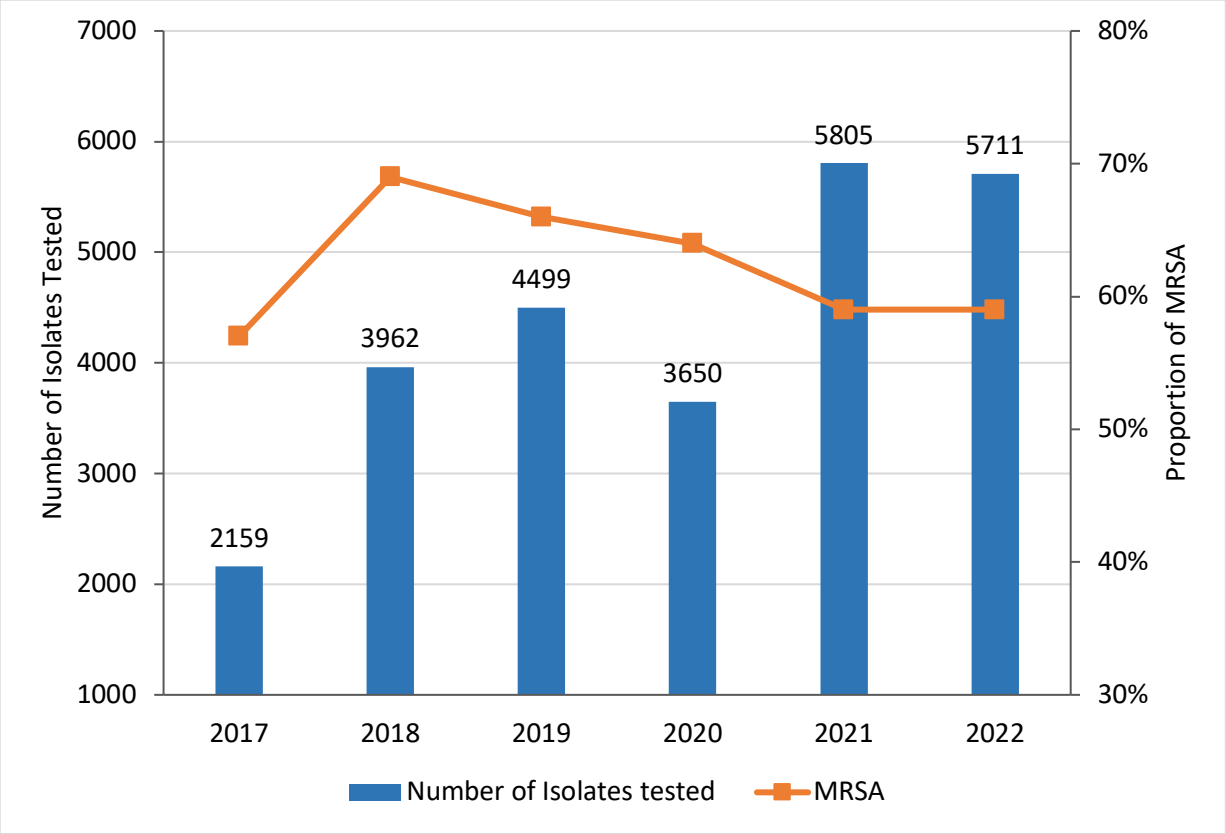
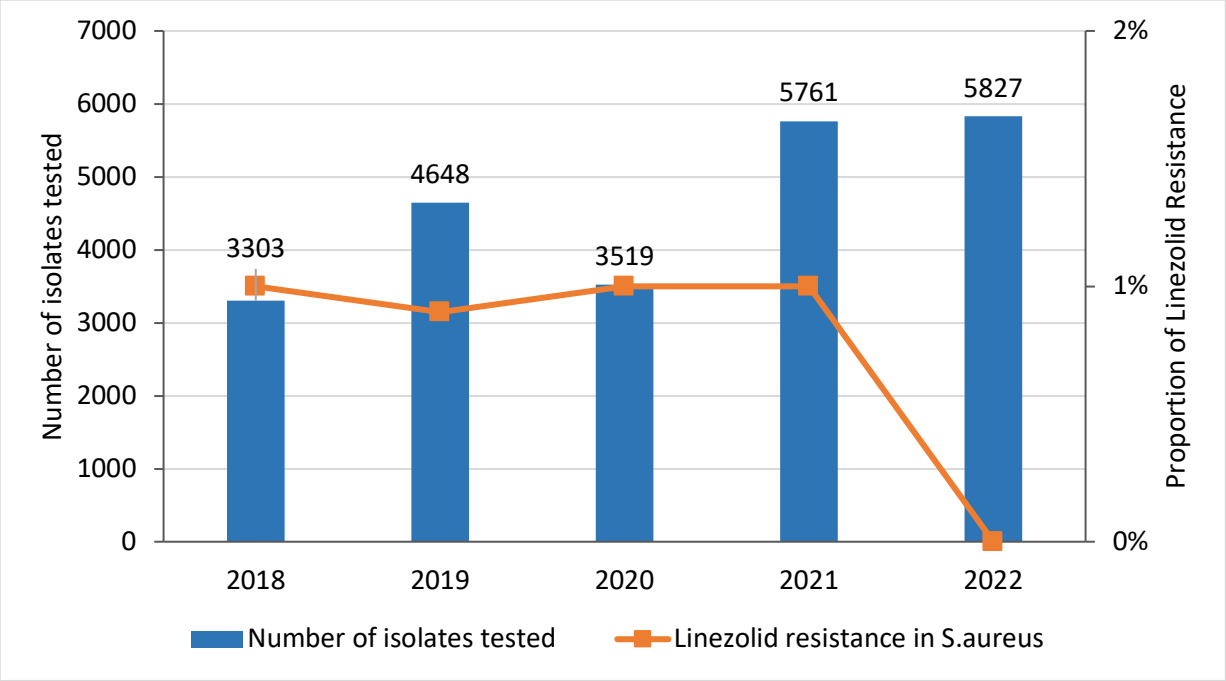


Figure 7: Trends of Methicillin-resistant *S. aureus* (MRSA)isolated from blood (2017-2022)

To observe significance in the trend of MRSA over the past 6 years, a linear trend analysis for MRSA isolates in blood was done using Chi-square for trend (Extended Mantel Haenszel) and a significant decrease in the proportion of MRSA in blood was seen from the year 2018 (69%) to 2021 (59%) and when compared to 2021 the proportion of MRSA has remained constant in the year 2022 (59%) (Chi-square value for Linear trend-18.9, p value - <0.0001).

Linezolid resistance in *S. aureus* isolated from blood has been consistently found to be lower than 1% in the last five years. However, in the year 2022, none of the *S. aureus* reported from blood were found to be resistant to linezolid [Fig. 8].



*Only the Alert pathogens confirmed at NRL, NCDC included in the data

Figure 8- Trends of Linezolid resistant *S. aureus* isolated from blood (2018 to 2022)

Out of 11,151 isolates tested on Vancomycin screen agar, only 9 isolates showed a growth. On further confirmation by Broth micro dilution, only one isolate showed resistance to Vancomycin. This resistance was confirmed at the NRL in NCDC.

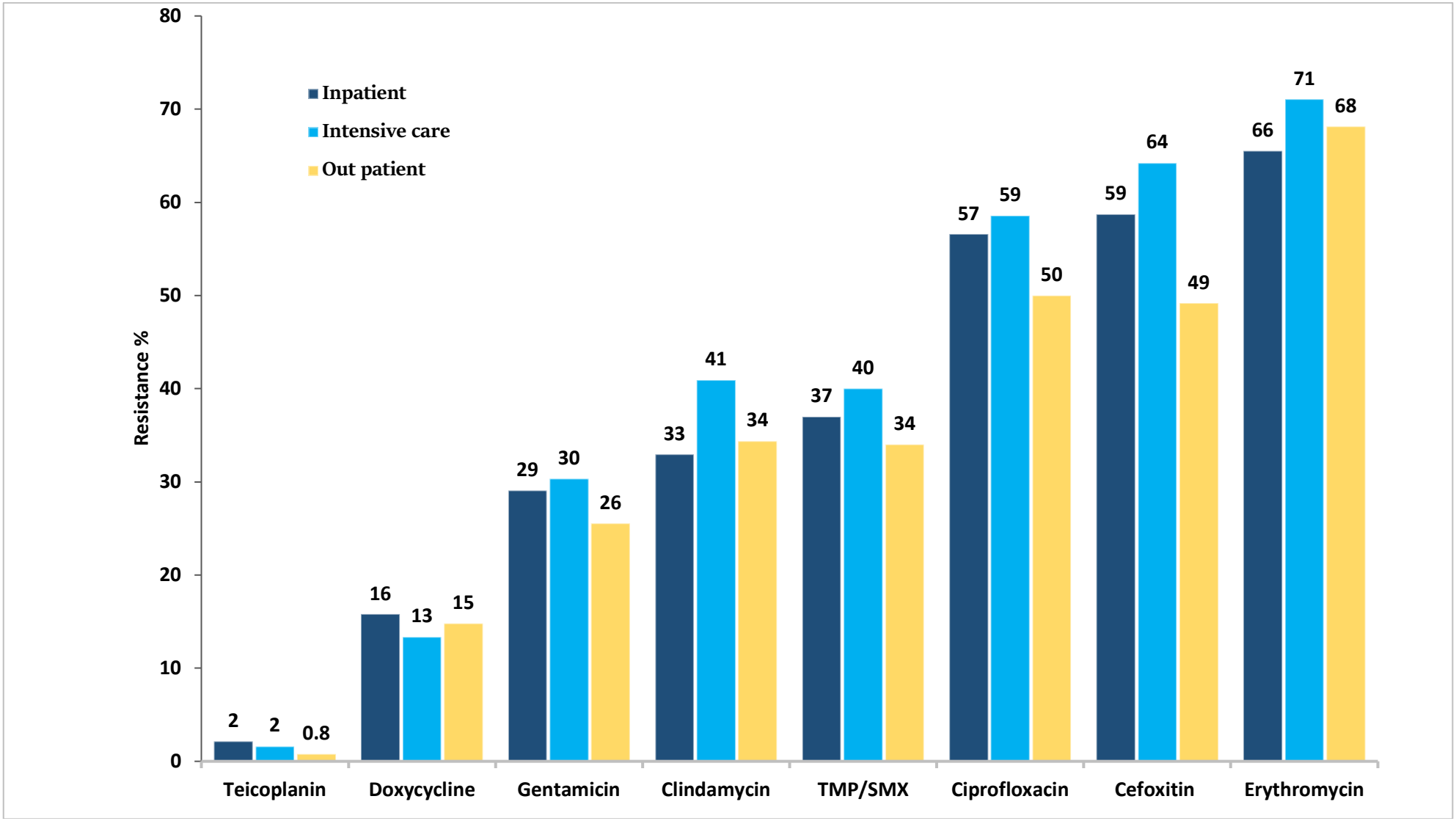
Among the Gram-positive cocci (GPC) isolated from the surveillance sites, *S. aureus* was the most isolated GPC from all the location settings like Inpatient wards (63%), Outpatient clinics (58%), Intensive care settings (55%) and from the emergency department (77%). Resistance to all the surveillance panel antibiotics were found to be proportionately higher among isolates from intensive care setting in comparison to those from outpatient clinics and the inpatient wards as seen in (Fig. 9)

Table 5: Resistance profile of *Staphylococcus aureus* (N=17,707)

Antibiotic tested	Blood (N=6256)			Pus Aspirate (N=10695)			Other Sterile Body Fluids (N=756)		
	Number Tested	(%R)	95% CI	Number Tested	(%R)	95% CI	Number Tested	(%R)	95% CI
Cefoxitin	5711	(59)	57.9-60.4	9530	(53)	51.5-53.5	688	(47)	43.0-50.6
Ciprofloxacin	5555	(56)	55.2-57.8	8788	(62)	61.3-63.3	619	(49)	45.3-53.3
Clindamycin	5947	(35)	33.7-36.1	10034	(20)	19.1-20.7	722	(28)	24.4-31.0
Doxycycline	5264	(15)	14.2-16.2	7842	(9)	8.8-10.1	601	(13)	10.1-15.6
Erythromycin	5880	(67)	65.8-68.2	9824	(56)	54.8-56.7	716	(64)	59.9-67.1
Gentamicin	5489	(29)	27.8-30.3	9128	(25)	24.0-25.7	671	(23)	19.9-26.4
Linezolid*	5827	(0)	0-0.1	9873	(0.01)	0-0.1	706	(0)	0-0.1
TMP/SMX	5313	(38)	36.4-39.0	8968	(20)	19.6-21.3	619	(32)	28.2-35.7
Teicoplanin	525	(2)	0.8-3.3	621	(3)	1.7-4.4	81	(2)	0.4-9.5

*Alert pathogens confirmed at NRL, NCDC only were included in the data

TMP/SMX -Trimethoprim/sulfamethoxazole



*Data of the emergency department was clubbed with data from inpatient wards

TMP/SMX -Trimethoprim/sulfamethoxazole

Figure 9 – Resistance profile of *S. aureus* in blood by location type (N=6256)

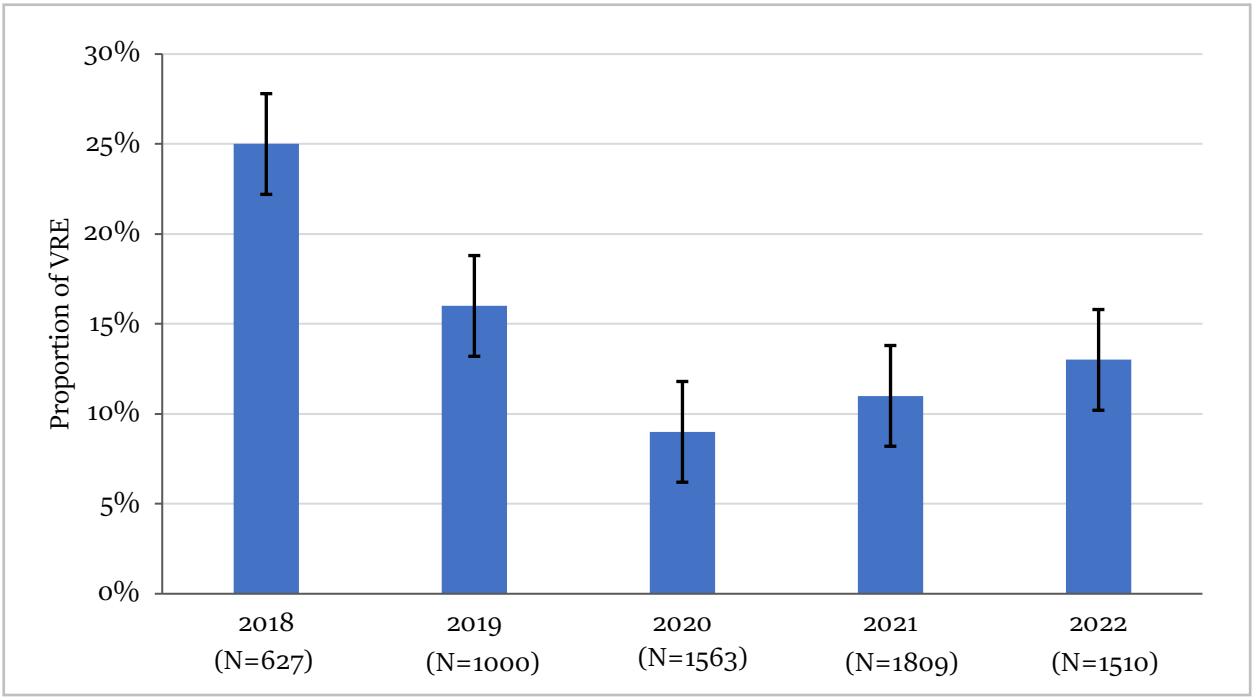
2. *Enterococcus species*

Enterococcus species contributed to a total of 9% amongst the seven priority pathogens isolated at the surveillance sites (Fig. 5) while it contributed to 38% of the total Gram-positive cocci isolates. A total of 11,457 *Enterococcus* species isolate data was submitted by the NARS Net sites of which 11,072 isolates were from unique patients. Upon analysis of 11,702 unique patient isolate data, it was observed that isolation rates from the specimens of blood, pus aspirates, other sterile body fluids and urine were 9%, 3%, 8% and 14% respectively [Table 3].

Among *Enterococcus* species isolated from blood, Erythromycin resistance was observed to be higher (78%, CI: 76.1- 80.0) followed by Ampicillin (65%, CI: 63.1-67.6). Similar resistance pattern was also observed in other specimen types like pus aspirate and sterile body fluids. (Table 6). Lowest proportion of resistance was reported to linezolid amongst enterococci isolated from all specimen types - blood (0.2%, CI: 0.1- 0.7), pus aspirate (0.08%, CI:0.0-0.6), other sterile body fluid (0.6%, CI: 0.1 -1.8).

Among the urinary isolates, more than half of the isolates were resistant to first line antibiotic ampicillin. Highest resistance was reported to the antibiotic Ciprofloxacin amongst all urinary isolates of *Enterococcus* species. Small proportion of the isolates from urine were resistant to high end antibiotics namely linezolid and Vancomycin - 0.13 % (CI: 0.1-0.3) and 9% (CI: 7.9- 9.4) respectively. [Table 6]

In comparison with the other priority pathogens under the programme, *Enterococcus* species was the least commonly isolated pathogen from various location types [Table 4]. Upon AST analysis of blood isolates from various location types in healthcare facilities, resistance to the entire panel of antibiotics was found to be higher in isolates from intensive care units in comparison to the inpatient wards and outpatient clinics (Fig. 11)



*Alert pathogens confirmed at NRL, NCDC only were included in the data

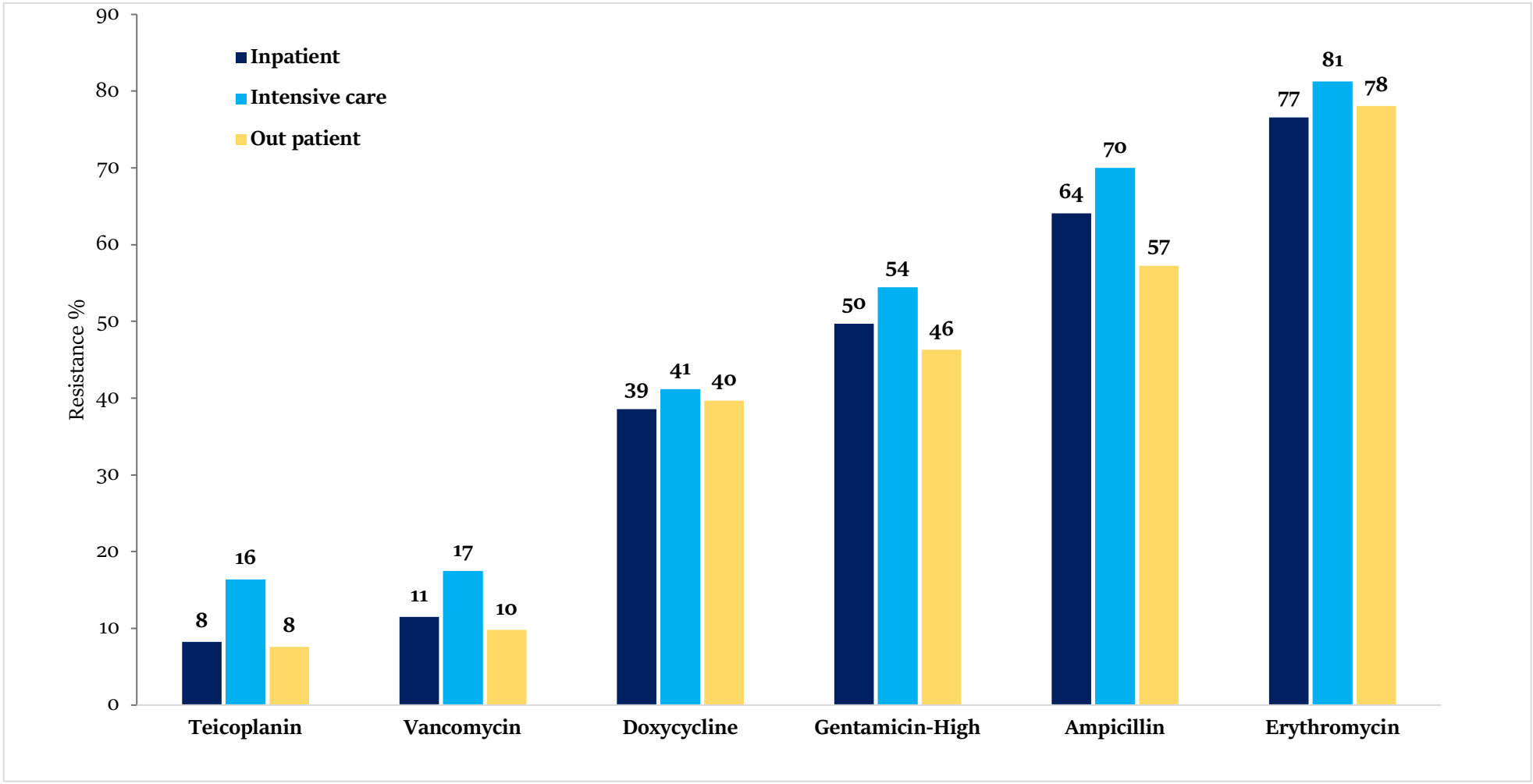
Figure 10-Trends of Vancomycin resistant *Enterococcus* spp. (VRE) isolated from blood (2018-2022)

To observe the trend of VRE in the past 5 years, a linear trend Analysis for VRE for blood isolates was done using Chi-square for trend (Extended Mantel Haenszel) and it was found that there is significant decrease in the proportion of VRE isolated from blood since the year 2018 (25%) to 2020 (9%), followed by a peak in 2022 (13%) (p value - <0.0001)

Table 6- Resistance profile of *Enterococcus* species (N=11,072)

Antibiotic Tested	Blood (N=2142)			Pus Aspirate (N=1250)			OSBF (N=567)			Urine (N=7113)		
	Number Tested	(%R)	95% CI	Number Tested	(%R)	95% CI	Number Tested	(%R)	95% CI	Number Tested	(%R)	95% CI
Ampicillin	1772	(65)	63.1-67.6	1086	(44)	41.4-47.4	493	(58)	53.1-62.0	6235	(59)	57.7 -60.2
Doxycycline	1658	(39)	37.1-41.8	1012	(44)	40.6-46.8	473	(46)	41.8-50.9	x		
Erythromycin	1829	(78)	76.1-80.0	1137	(72)	69.7-74.9	522	(75)	70.9-78.5	x		
Gentamicin-H	1733	(51)	48.6-53.3	1127	(34)	31.8-37.4	498	(50)	45.3-54.3	6301	(53)	51.9-54.3
Linezolid*	1833	(0.2)	0.1-0.7	1159	(0)	0.0-0.6	531	(0.6)	0.1-1.8	6556	(0.1)	0.1-0.3
Teicoplanin	810	(10)	8.4-12.7	415	(5)	3.2-7.8	219	(14)	10.0-19.6	2266	(16)	14.8-17.9
Vancomycin*	1809	(13)	11.6-14.8	1032	(5)	3.7-6.5	543	(12)	9.4-15.1	6033	(9)	7.9-9.4
Ciprofloxacin	x			x			x			5775	(76)	74.5-76.7
Tetracycline	x			x			x			4578	(65)	63.9-66.7
Fosfomycin	x			x			x			1438	(11)	9.2-12.5

*Alert pathogens confirmed at NRL, NCDC were included in the data



*Data of the emergency department was clubbed with data from inpatient wards

Figure 11- Resistance profile of *Enterococcus* species in blood by location type (N=2142)

B. Gram Negative Bacilli

Under NARS Net, the five most commonly isolated gram-negative bacilli of public health importance are included for AMR surveillance. These are *Escherichia coli, Klebsiella* species, *Pseudomonas* species, *Acinetobacter* species and *Salmonella* enterica serovar Typhi and Paratyphi. AST data of 98,378 isolates of gram-negative bacilli have been reported from 90,907 unique patients during the period of January 2022 to December 2022 from 36 sentinel sites.

1. Enterobacteriaceae

E. coli, Klebsiella species and *Salmonella enterica* serovar Typhi and Paratyphi isolate data submitted by network sites included 69,942 isolates from 64,441 unique patients. Among all the priority pathogens in the data reporting period, *Enterobacteriaceae* contributed to the 54% of total number of isolates and to 71% of all the gram-negative bacteria reported by the sentinel sites.

a) Escherichia coli

A total of 43,136 *E. coli* isolates were reported from 39,620 unique patients. *E. coli* isolates have contributed to one-third of the unique patient AST data of the year 2022 (Fig. 5). *E coli* was most frequently isolated from urinary sample (53%) followed by sterile body fluids (23%), pus (22%) and blood (11%) (Table 3). Among all the antibiotics tested, highest resistance in isolates from all specimen types - blood, pus aspirate, sterile body fluid and urine- was observed to the antibiotic ampicillin (Table 7). Among the third generation cephalosporins, 76% (CI:74.1-78) resistance was observed to the drug cefotaxime in blood isolates and similar high level of resistance was seen in isolates from other specimen types.

In urinary isolates, carbapenem resistance in *E. coli* was observed to be 35% whereas among non-beta-lactam antibiotics, 74% (CI: 72.9-74.1) resistance was observed to ciprofloxacin, 58% (CI:57.3- 58.6) to Trimethoprim-Sulfamethoxazole (TMP/SMX) and 9% (CI:8.9- 9.6) to nitrofurantoin (Table 7). About one-third of urinary isolates (75%) were found to be resistant to the second-generation cephalosporin cefuroxime. Colistin susceptibility testing has been done using the broth microdilution method as per CLSI document M02 and M100. In the 2022

data three isolates from pus aspirate and one from urine showed resistance to colistin and these resistant isolates were further confirmed at the NRL at NCDC.

In the location type wise resistance profile among blood isolates of *E. coli*, higher resistance was observed in isolates from the intensive care units to all the antibiotics in the surveillance panel in comparison to inpatient wards and out patient clinics (Fig. 13).

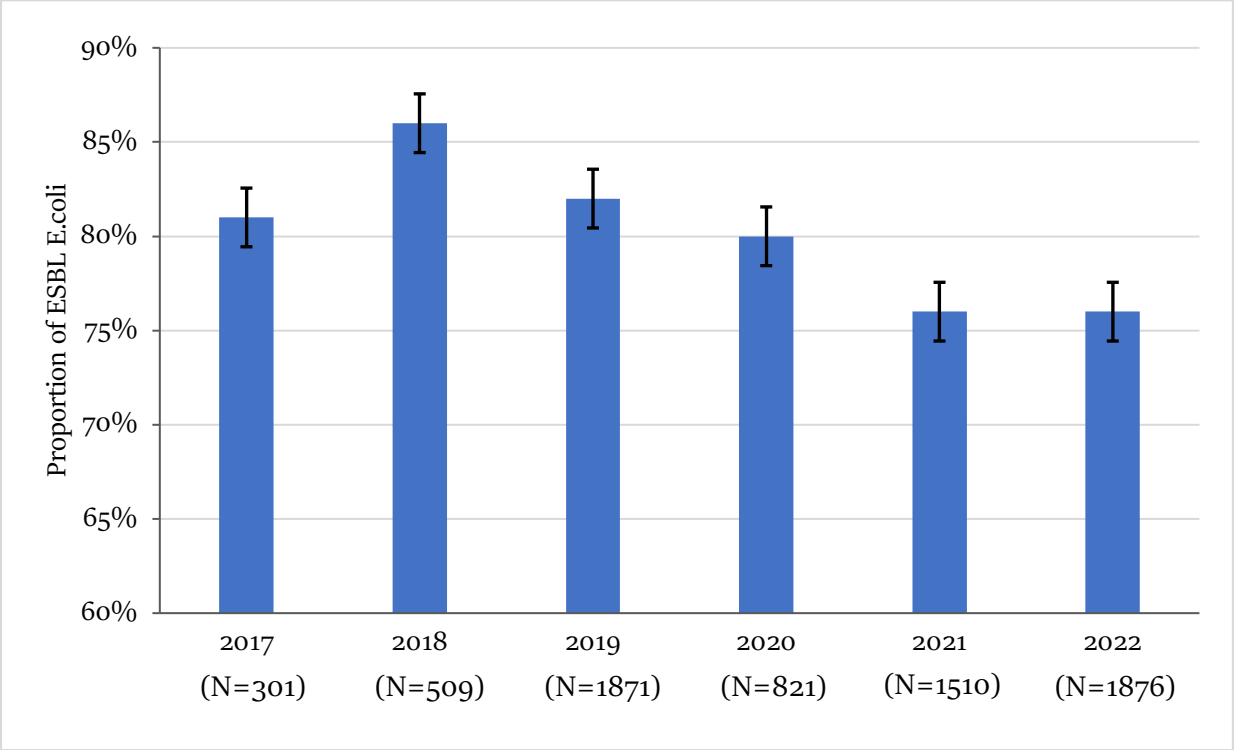


Fig 12: Trends of Extended spectrum beta-lactamase (ESBL) producing *E. coli* isolated from blood [2017-2022]

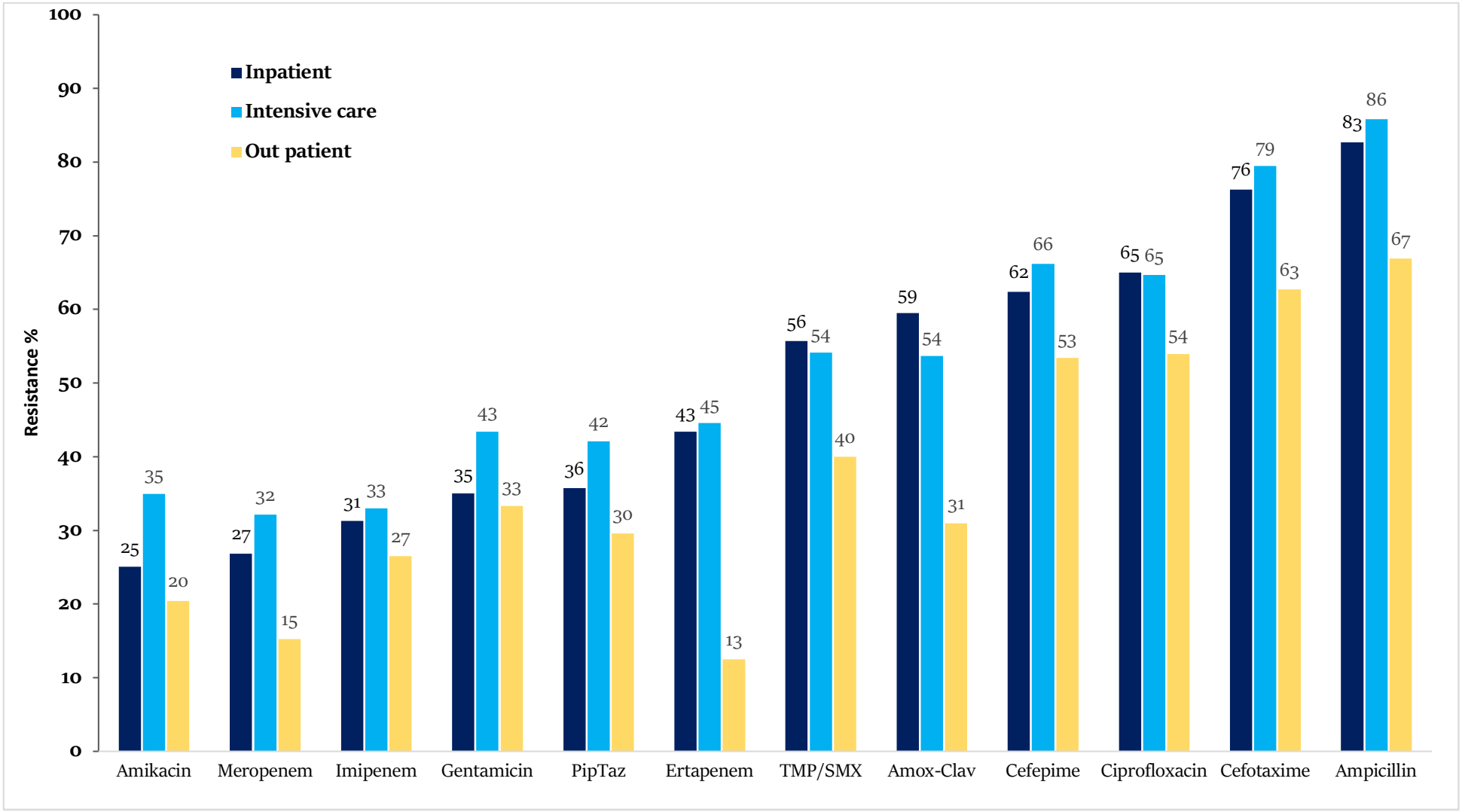
The linear trend Analysis for ESBL producing *E. coli* (Blood) was done using Chi-square for trend (Extended Mantel Haenszel) and a significant decrease was observed in the proportion of ESBL in *E. coli* isolates from the year 2018 (81%) to 2021 (76%) and has remained constant in the current data reporting period of 2022 (p value - <0.0001).

Table 7: Resistance profile of *Escherichia coli* (N=39,620)

Antibiotic Tested	Blood (N=2496)			Pus Aspirate (N=8297)			OSBF (N=1548)			Urine (N=27279)		
	Number Tested	(% R)	95% CI	Number Tested	(% R)	95% CI	Number Tested	(%R)	95% CI	Number Tested	(% R)	95% CI
Amikacin	1952	(27)	25.3-29.4	6826	(24)	22.6-24.6	1170	(24)	21.7-26.7	17259	(19)	18.8-20.0
Amox-clav	1054	(57)	53.5-59.6	4108	(59)	57.0-60.1	677	(61)	57.7-65.1	10955	(49)	47.9-49.8
Ampicillin	1725	(82)	80.4-84.1	5692	(89)	87.6-89.3	1051	(88)	85.5-89.5	19886	(86)	85.7-86.6
Cefepime	1920	(63)	60.6-65.0	6491	(64)	62.9-65.3	1257	(67)	64.5-69.8	20423	(58)	57.4-58.8
Cefotaxime	1876	(76)	74.1-78.0	6581	(80)	78.8-80.7	1234	(81)	78.6-83.1	23247	(75)	74.1-75.2
Ciprofloxacin	2069	(64)	62.1-66.2	6721	(75)	74.2-76.3	1276	(76)	73.7-78.5	23227	(74)	72.9-74.1
Colistin	1683	(0)	0.0-0.1	4286	(0.1)	0-0.2	1080	(0)	0.0-0.1	7589	(0.01)	0-0.1
Ertapenem	603	(43)	39.0-47.0	1275	(33)	30.5-35.7	335	(44)	38.2-49.1	4520	(32)	30.7-33.5
Gentamicin	1788	(37)	34.8-39.4	5762	(34)	33.0-35.5	917	(34)	31.0-37.2	11518	(27)	26.1-27.7
Imipenem	1983	(31)	29.4-33.6	6633	(28)	26.5-28.7	1289	(32)	29.8-35.0	21065	(21)	20.5-21.6
Meropenem	1227	(28)	25.5-30.6	4523	(21)	19.9-22.3	652	(27)	23.8-30.8	8814	(18)	16.9-18.5
Piperacillin/ Tazobactam	1887	(37)	34.8-39.2	6194	(36)	34.6-37.0	1121	(41)	37.7-43.5	14039	(24)	23.1-24.5
TMP/SMX	1909	(54)	51.8-56.4	6715	(59)	57.3-59.7	1260	(59)	56.4-61.9	23163	(58)	57.3-58.6
Nitrofurantoin	x			x			x			24953	(9)	8.9-9.6
Fosfomycin	x			x			x			4978	(3)	2.3-3.2
Cefuroxime	x			x			x			6707	(75)	73.6-75.7
Doxycycline	x			722	(35)	31.2- 38.2	139	(32)	24.2- 4.02	x		

x- Drug bug combination for the specimen type not tested in NARS-Net surveillance panel

TMP/SMX - Trimethoprim/sulfamethoxazole
Amox-clav -Amoxicillin/Clavulanic acid



*Data of the emergency department was clubbed with data from inpatient wards

Amox-clav -Amoxicillin/Clavulanic acid

TMP/SMX - Trimethoprim/sulfamethoxazole

PipTaz – Piperacillin-Tazobactam

Figure 13: Resistance profile of *Escherichia coli* in blood by location type (N=2496)

b) Klebsiella species

In the current data reporting period, a total of 26,351 *Klebsiella* spp. isolates were reported of which 24,377 were unique patient isolates.

Among the urinary isolates of *Klebsiella* spp., 7 in 10 of were found to be resistant to a second and third generation cephalosporins. Resistance to ertapenem (42%, CI:40.1- 44.7) was highest amongst the carbapenems. One third of the isolates tested against aminoglycosides like amikacin (34%, CI:32.4- 34.6) were found to be resistant meanwhile a 36% (CI: 35.3- 37.3) resistance was observed to nitrofurantoin (Table 8).

Like urinary isolates, *Klebsiella* spp. isolated from blood samples showed higher resistance towards the second and third generation cephalosporins. Carbapenem resistance in *Klebsiella* spp. isolated from blood was found to be 47%. Similar pattern of resistance was also observed in isolates from pus aspirate and sterile body fluids. Resistance to colistin was found to be highest in isolates of *Klebsiella* spp. when compared to other gram-negative priority pathogens isolated from all specimen types. These resistant isolates were further confirmed at the NRL in NCDC (Table 8).

The location type wise AST of *Klebsiella* spp. revealed a resistance pattern like other priority pathogens wherein higher resistance was observed in isolates from intensive care units as compared to inpatient wards and outpatient clinics (Fig. 14).

Table 8: Resistance profile of *Klebsiella* species (N=24,377)

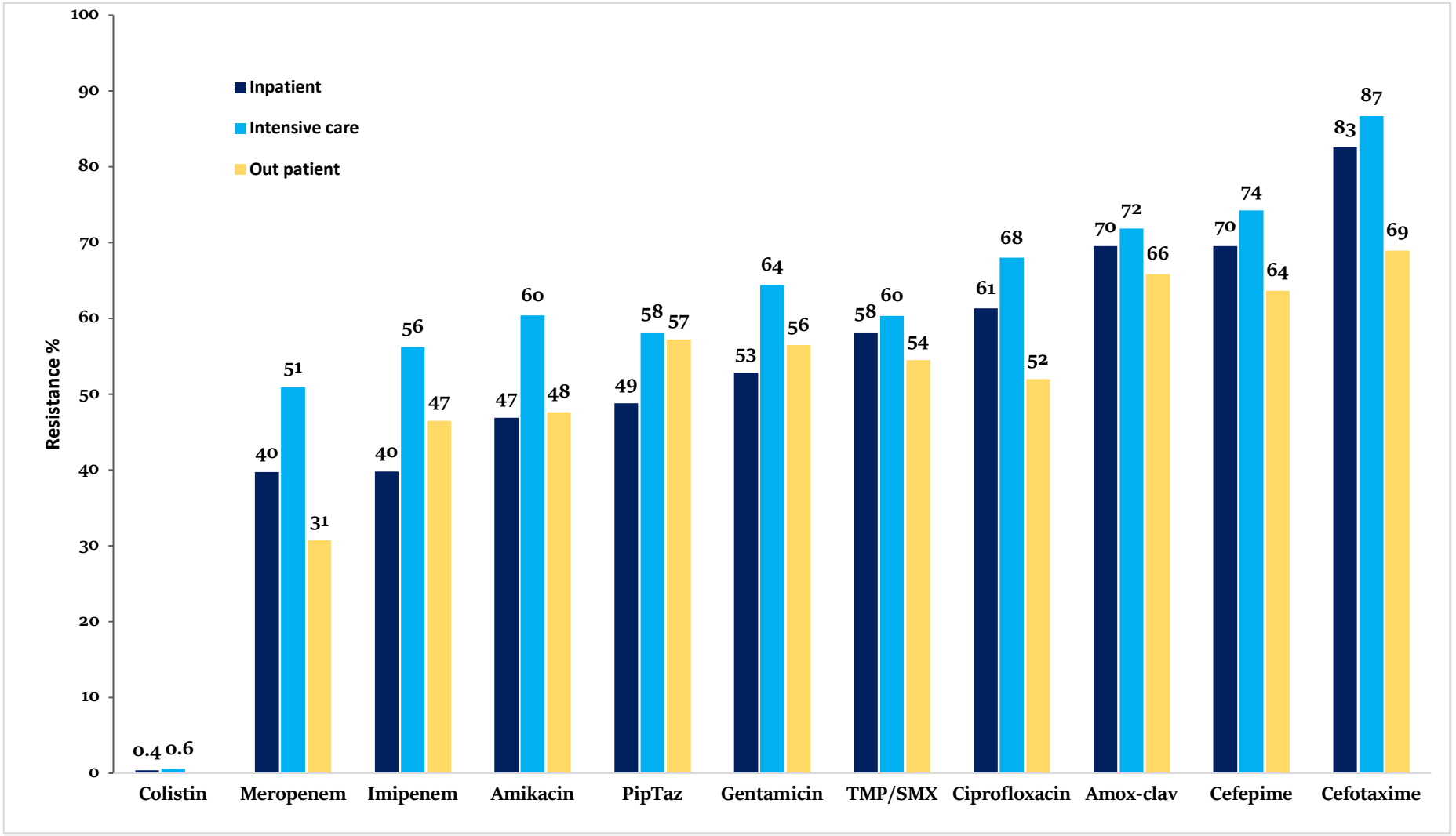
Antibiotic Tested	Blood (N=4639)			Pus aspirate (N=7592)			OSBF (N=1380)			Urine (N=10766)		
	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI
Amikacin	3258	(52)	50.0-53.4	6393	(42)	40.7-43.1	998	(41)	37.8-44.0	7180	(34)	32.4-34.6
Amox-clav	1617	(70)	67.9-72.4	3589	(68)	66.5-69.6	527	(70)	65.7-73.7	4567	(57)	56.0-58.9
Cefepime	3645	(71)	69.1-72.1	6172	(66)	65.1-67.4	1092	(65)	62.4-68.1	8224	(57)	56.4-58.5
Cefotaxime	3631	(83)	81.5-84.0	6280	(76)	75.4-77.5	1122	(75)	72.6-77.7	9262	(69)	67.6-69.5
Ciprofloxacin	3935	(63)	61.3-64.3	6465	(68)	67.0-69.3	1150	(65)	61.7-67.3	9416	(60)	59.4-61.4
Colistin*	3071	(0.4)	0.2-0.7	3941	(0.2)	0.1-0.4	913	(0.2)	0-0.9	3702	(0.3)	0.2-0.6
Ertapenem		x		890	(42)	38.9-45.5	214	(56)	48.7-62.3	1816	(42)	40.1-44.7
Gentamicin	3076	(57)	55.4-58.9	5605	(48)	46.9-49.5	832	(49)	45.2-52.1		x	
Imipenem	3786	(46)	44.1-47.3	6225	(39)	37.6-40.1	1128	(43)	40.0-45.9	8614	(30)	28.9-30.9
Meropenem	2153	(44)	41.6-45.9	4764	(34)	32.5-35.2	601	(37)	33.1-41.0	3559	(28)	26.1-29.1
Piperacillin/ Tazobactam	3414	(53)	51.1-54.5	6154	(47)	45.6-48.1	1012	(46)	42.8-49.0	5952	(32)	30.5-32.9
TMP/SMX	3691	(59)	57.0-60.2	6367	(58)	57.0-59.4	1104	(63)	59.9-65.7	9141	(55)	53.5-55.6
Cefuroxime		x			x			x		2984	(70)	68.8-72.1
Nitrofurantoin		x			x			x		8868	(36)	35.3-37.3
Doxycycline		x		640	(37)	33.3-40.9	100	(34)	25.0-44.2		x	

*Alert pathogens confirmed at NRL, NCDC only were included in the data

x- Drug bug combination for the specimen type not tested in NARS-Net surveillance panel

TMP/SMX - Trimethoprim/sulfamethoxazole

Amox-clav -Amoxicillin/Clavulanic acid



*Data of the emergency department was clubbed with data from inpatient wards

TMP/SMX - Trimethoprim/sulfamethoxazole
PipTaz – Piperacillin-Tazobactam

Figure 14: Resistance profile of *Klebsiella* species in blood by location type (N=4639)

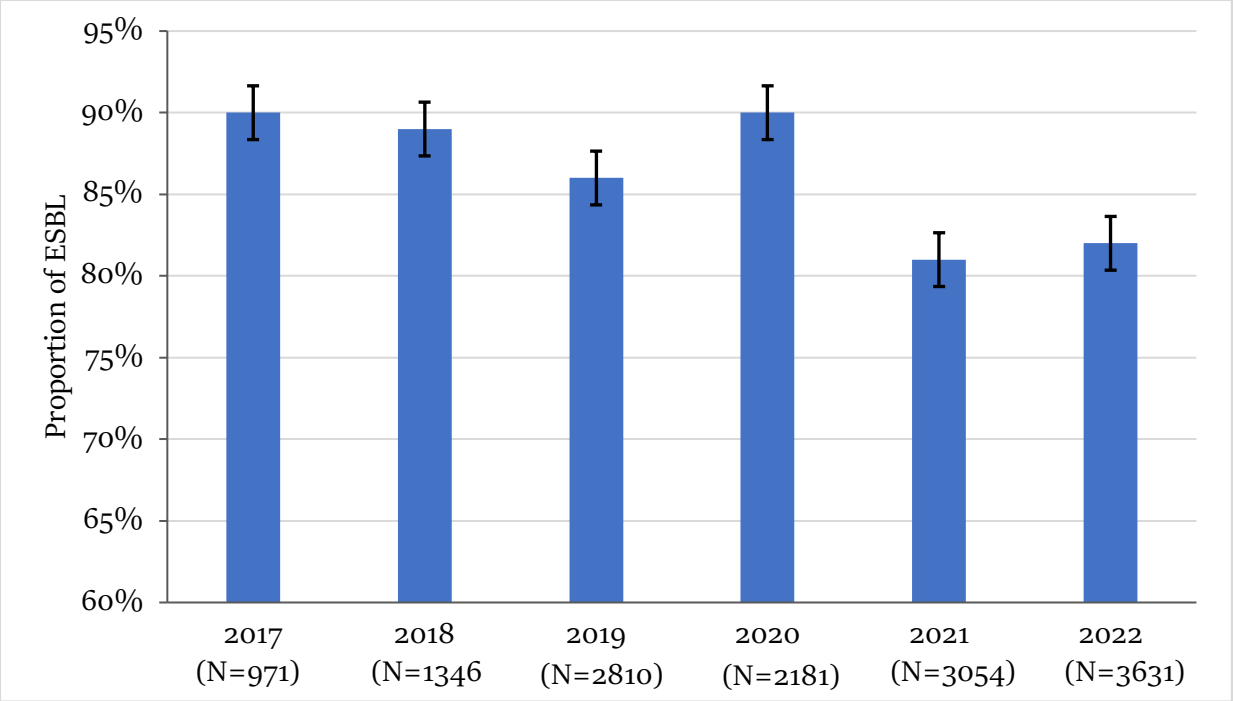


Figure 15 - Trends of Extended-Spectrum Beta-Lactamase (ESBL) producing *Klebsiella* sp. in blood (2017-2022)

The linear trend Analysis for ESBL in *Klebsiella* spp. (Blood) was done using Chi-square for trend (Extended Mantel Haenszel) and it was found that there is a significant decrease in the proportion of ESBL in Klebsiella isolates from 2018 to 2019 followed by an upward trend in 2020 (90%). Further in 2022 the proportion of ESBL producing bacteria significantly decreased to 82% (p value - <0.0001) [Fig 15]

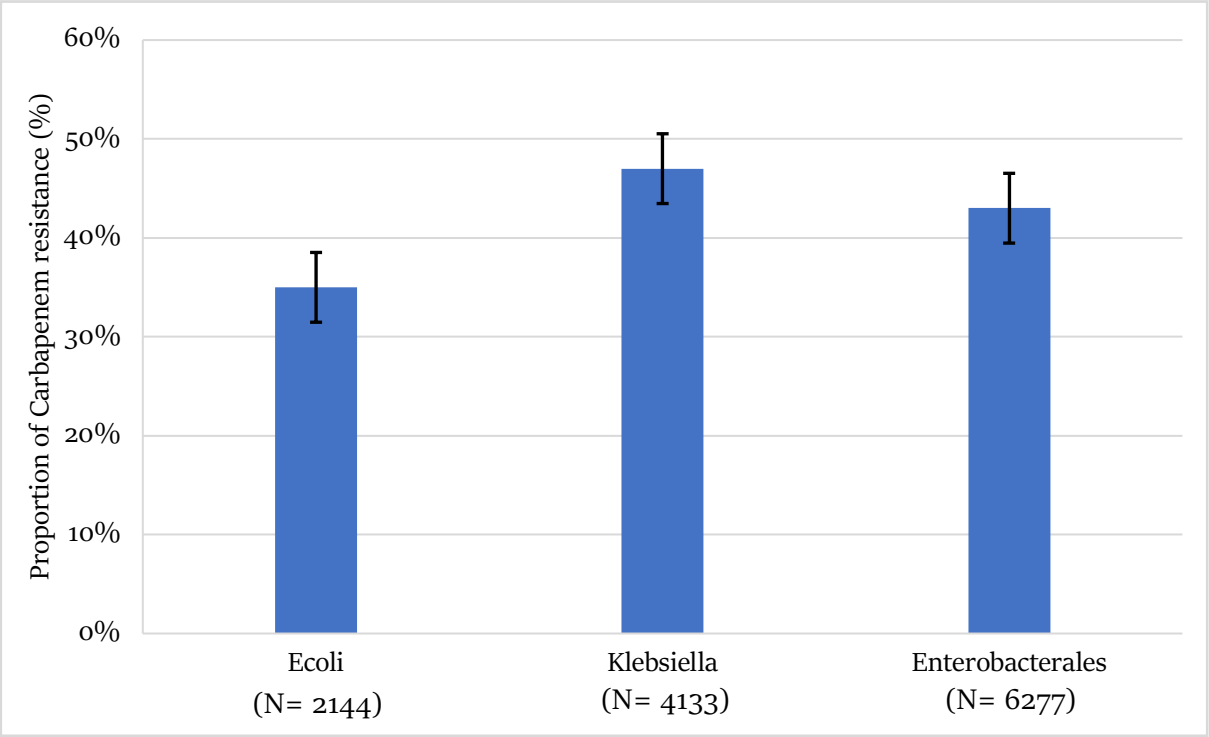


Figure 16- Carbapenem resistance among Enterobacterales isolated from blood

One third of *E. coli* (35%) isolates from blood showed resistance to at least one of the carbapenems whereas nearly half of the *Klebsiella* spp. (47%) isolates from blood were resistant to at least one of the carbapenems namely imipenem or ertapenem or meropenem. Among the Enterobacterales (CRE) carbapenem resistance was observed in 43% of isolates.

Salmonella enterica Typhi and Paratyphi

In the current data reporting period 455 *Salmonella enterica* serovar Typhi and Paratyphi were submitted to NCDC of which 444 isolates were from unique patients. Ten of these isolates were reported from stool specimens. Compared to ciprofloxacin, lower resistance rates to first-line antibiotics like ampicillin, chloramphenicol and Trimethoprim/ Sulfamethoxazole were observed. Only two isolates of *Salmonella* enterica serovar Typhi were found to be resistant to ceftriaxone and no resistance was observed against imipenem. (Table 9)

Table 9: Resistance profile of *Salmonella* enterica Typhi and Paratyphi (N=444)

Antibiotic tested	*S. Typhi* (N=381)			*S. Paratyphi* (N=53)	
	Number tested	Resistance (%)	95% CI	Number tested	(Number Resistant)
Ampicillin	358	(6)	4.2-9.6	50	(7)
Azithromycin*	323	(0)	0.0-0.1	42	(0)
Ceftriaxone*	353	(0.6)	0.1-2.3	46	(0)
Chloramphenicol	327	(4)	2.5-7.2	48	(4)
Ciprofloxacin	359	(29)	24.7-34.3	48	(11)
Imipenem*	325	(0)	0.0-0.1	46	(0)
Trimethoprim/Sulfamethoxazole	370	(5)	3.2-8.0	50	(1)

*Alert pathogens confirmed at NRL, NCDC only were included in the data

2. Non-Fermenting Gram-Negative Bacilli

Among the Non-fermenting Gram-negative bacilli (NF GNB) collected during Jan-Dec 2022 across all NARS-Net sentinel sites, *Pseudomonas* species (14,684) were the most frequently isolated pathogen followed by *Acinetobacter* species (11,782). In the current data, *Pseudomonas* species was predominantly isolated from inpatients (12 %), and *Acinetobacter* species was predominant among isolates from ICU settings (19 %).

i. *Pseudomonas* species

NARS-Net surveillance sites in the year 2022 reported 15,892 isolates of *Pseudomonas* spp. from 14,684 unique patients. Among the priority pathogens isolated from various specimen types, *Pseudomonas* spp. was isolated from 11% blood cultures, 17% pus aspirates, 18% sterile body fluids and 8% urine (Table 3).

About 50% of urinary isolates were observed to be resistant to at least one of the third generation cephalosporin with a similar resistance pattern in non-beta lactams like ciprofloxacin and gentamicin. *Pseudomonas* spp. isolated from blood samples showed 44% resistance to ceftazidime whereas around 30% resistance was observed to ciprofloxacin and gentamicin each. The carbapenem resistance in blood isolates of pseudomonas was observed to be 27% (Table 10).

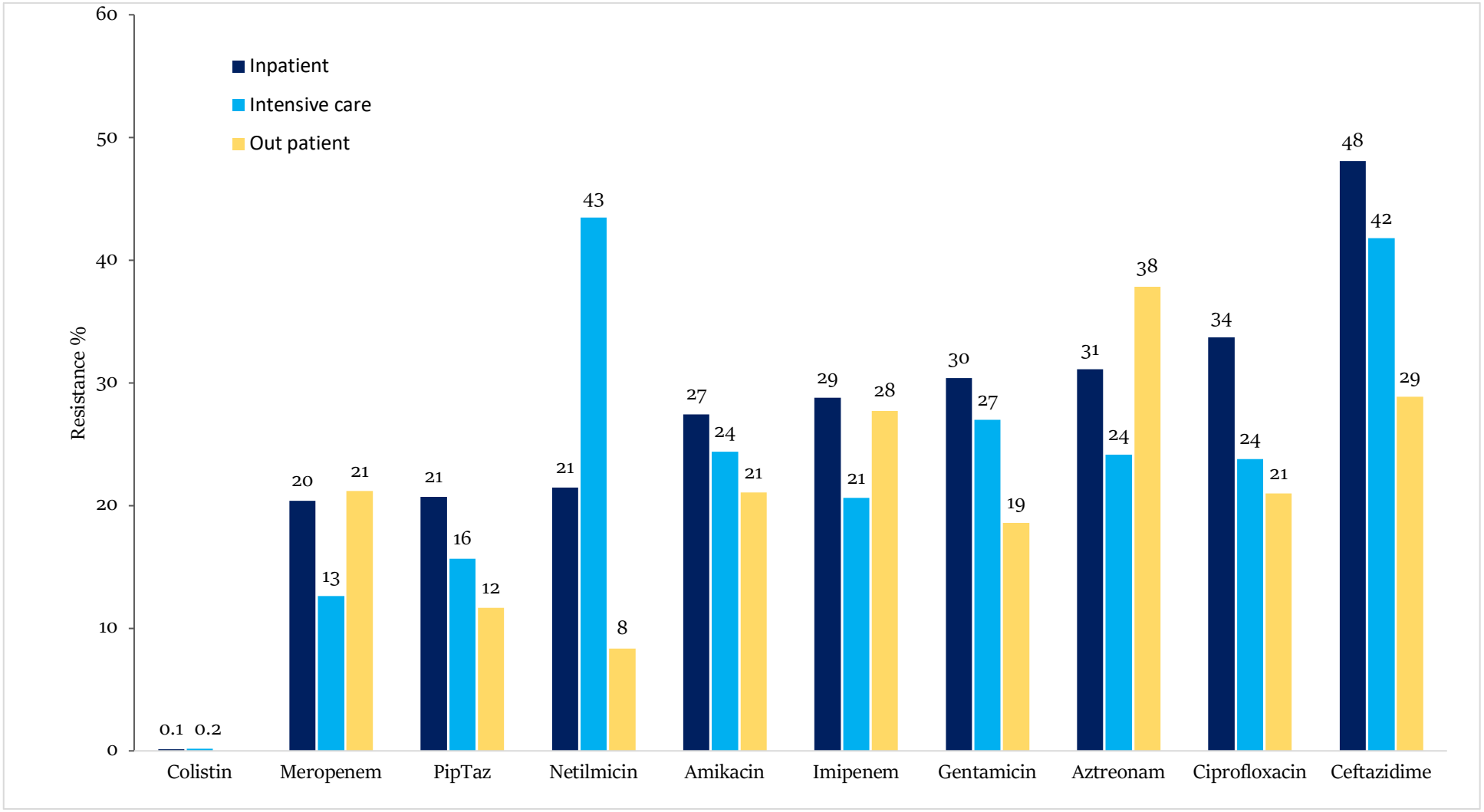
With regard to reserve group of antibiotics like Colistin, two isolates from blood, one from pus aspirate, two from sterile body fluids and one from urine were found to be resistant and confirmed at the NRL at NCDC (Table 10).

Isolates of *Pseudomonas* spp. from blood samples from patients in Intensive care units, inpatient wards and outpatient clinics of healthcare facilities showed high resistance to ceftazidime.

Table 10: Resistance profile of *Pseudomonas* species (N=14684)

Antibiotic Tested	Blood (N=2457)			Pus Aspirate (N=6663)			OSBF (N=1181)			Urine (N=4383)		
	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI
Amikacin	2239	(26)	24.1-27.7	6199	(33	31.6-33.9	1050	28	25.0-30.5	3844	39	37.0-40.1
Aztreonam	1277	(36)	33.5-38.9	3330	(28	26.0-29.1	571	36	32.2-40.2	2123	37	35.2-39.4
Ceftazidime	2220	(44)	42.2-46.4	6070	(44	42.9-45.5	1073	36	33.4-39.2	3927	50	47.9-51.1
Ciprofloxacin	2154	(29)	27.3-31.1	5836	(44	43.1-45.7	1051	33	29.8-35.6	3883	52	50.1-53.3
Colistin	1561	(0.1)	0-0.5	3355	(0.03)	0-0.2	740	0.3	0-1.1	1615	0.06	0-0.4
Gentamicin	2142	(28)	26.2-30.1	5733	37)	35.6-38.1	979	29	26.4-32.2	3575	41	39.1-42.4
Imipenem	2098	(26)	24.2-28.0	5532	27)	25.4-27.7	1034	33	30.4-36.2	3508	35	33.9-37.1
Meropenem	1250	(17)	15.0-19.3	4390	(22)	20.3-22.8	488	28	23.8-31.9	1513	33	30.8-35.6
Netilmicin	260	(21)	16.5-26.7	996	(30)	26.7-32.5	109	24	16.4-33.1	520	32	28.2-36.3
Piperacillin/ Tazobactam	2224	(18)	16.7-20.0	6043	(22)	21.2-23.3	1067	22	19.6-24.7	3895	24	22.6-25.3

*Alert pathogens confirmed at NRL, NCDC only were included in the data



*Data of the emergency department was clubbed with data from inpatient wards

PipTaz – Piperacillin-Tazobactam

Figure 17-Resistance profile of *Pseudomonas* species in blood by location type (N=2457)

ii. Acinetobacter species

A total of 12,544 *Acinetobacter* species isolate data was submitted by network sites of which 11,782 were from unique patients. Among all specimen types reported under the programme, *Acinetobacter* species was isolated from 21% blood cultures, 19% other sterile body fluids, 9% pus aspirates and 4% urine samples.

Blood isolates showed a highest resistance 73% (CI: 71.8- 74.6) to Ceftazidime, similar resistance was also observed in other specimen types namely pus aspirate (80%), sterile body fluids (76%, CI:72.9- 78.2) and urine (66%, CI:64.1- 68.8).

Imipenem was resistant in 59% (CI: 57.1- 60.2) of blood isolates whereas the resistance rates were as high as 65% (CI: 63.3- 66.7) in isolates from pus aspirates and 69% (CI: 66.5- 72.0) in isolates sterile body fluids. Among blood isolates, resistance to any one of the carbapenems was observed to be 59%. Only 0.1% resistance was observed to Colistin among blood isolates of *Acinetobacter* species, however none of the isolates from pus aspirate, sterile body fluids or urine were found to be resistant to Colistin.

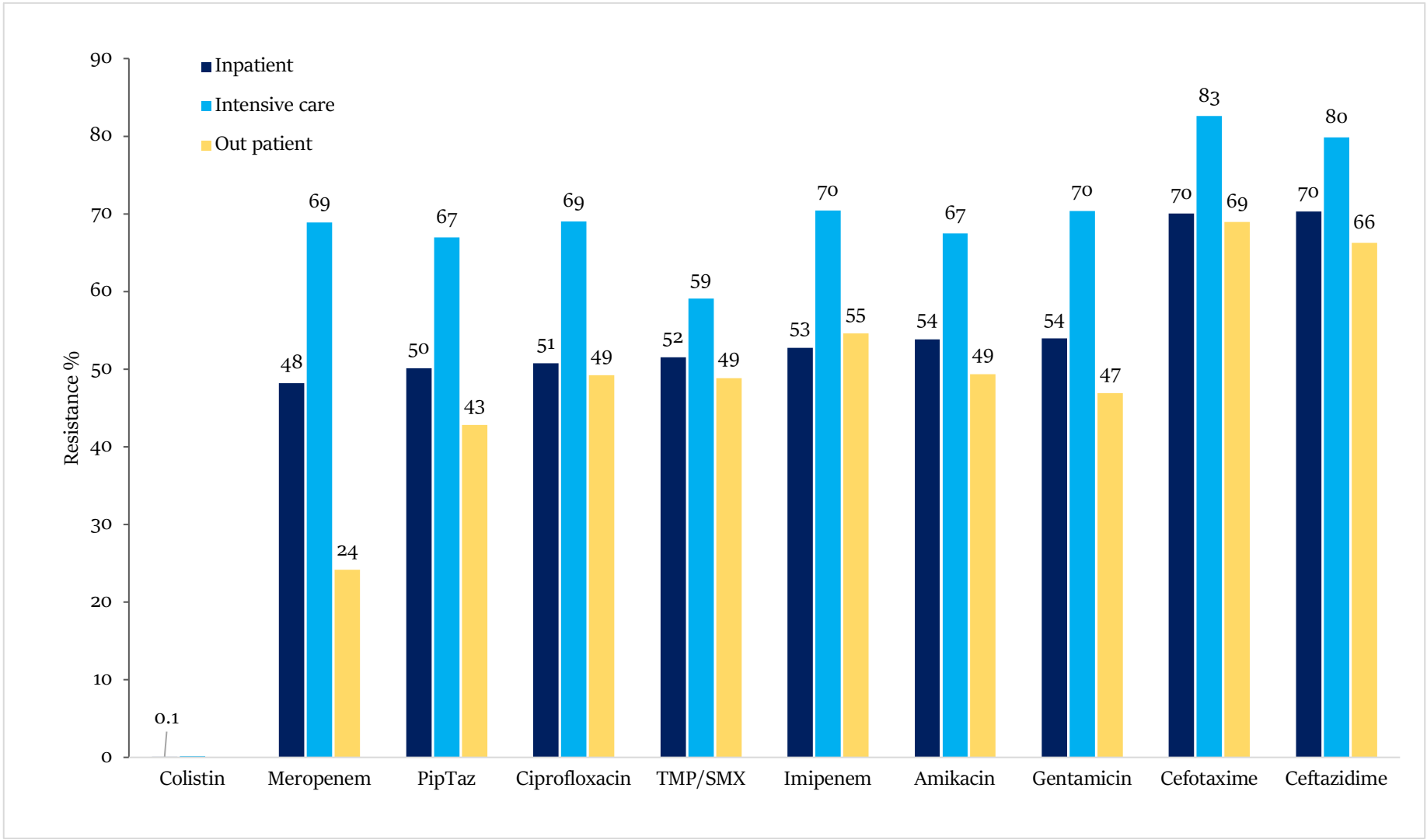
As compared to non-ICU settings, resistance rates were high in *Acinetobacter* species isolated from blood from ICU patients. (Figure 18). Colistin resistance was observed to be as low in 0.1% in Inpatients and imipenem resistance was as high as 70% in isolates from ICU. (Figure 18)

Table 11: Resistance profile of *Acinetobacter* species (N=11,782)

Antibiotic Tested	Blood (N=4820)			Pus Aspirate (N=3586)			OSBF (N=1285)			Urine (N=2091)		
	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI	Number Tested	(%R)	95 % CI
Amikacin	4086	(58)	56.5-59.5	3132	(67)	65.2-68.5	1107	(64)	60.9-66.6	1579	(44)	41.4-46.4
Ceftazidime	3954	(73)	71.8-74.6	3050	(80)	78.1-81.0	1043	(76)	72.9-78.2	1595	(66)	64.1-68.8
Ciprofloxacin	4189	(57)	55.2-58.2	3100	(74)	72.4-75.6	1102	(65)	62.5-68.2	1833	(50)	47.9-52.6
Colistin	3624	(0.1)	0-0.3	1968	(0)	0.0-0.1	937	(0)	0.0-0.1	830	(0)	0.0-0.1
Gentamicin	4174	(59)	57.3-60.3	2731	(67)	65.3-68.9	1065	(62)	59.1-65.0	1457	(45)	42.0-47.2
Imipenem	4109	(59)	57.1-60.2	3040	(65)	63.3-66.7	1120	(69)	66.5-72.0	1706	(41)	39.1-43.8
Meropenem	1513	(56)	53.4-58.5	1632	(58)	55.5-60.4	496	(63)	58.3-66.9	609	(35)	31.7-39.4
Piperacillin/ Tazobactam	4235	(55)	53.6-56.7	3093	(66)	64.1-67.5	1136	(59)	56.5-62.3	1835	(37)	34.6-39.1
Cefotaxime	2049	(74)	72.5-76.3	1578	(78)	76.1-80.2	636	(72)	68.8-75.9	1212	(58)	55.6-61.2
TMP/SMX	2661	(54)	52.5-56.3	2235	(68)	66.0-69.9	855	(60)	56.7-63.4	1334	(51)	48.0-53.4
Amikacin	4086	(58)	56.5-59.5	3132	(67)	65.2-68.5	1107	(64)	60.9-66.6	1579	(44)	41.4-46.4

*Alert pathogens confirmed at NRL, NCDC only were included in the data

TMP/SMX - Trimethoprim/sulfamethoxazole



*Data of the emergency department was clubbed with data from inpatient wards

PipTaz – Piperacillin-Tazobactam
TMP/SMX - Trimethoprim/sulfamethoxazole

Figure 18- Resistance profile of *Acinetobacter* species in blood by location type (N=4820)

V. Discussion

Antimicrobial resistance (AMR), recognized as the top ten public health threat by World Health Organisation, poses many threats across sectors, mandating the need to strengthen global, national, and local AMR surveillance. Data generated through AMR surveillance assists in monitoring antibiotic resistance trends and enables effective public health interventions.

Under the National Programme on AMR Containment, NCDC's National Antimicrobial Resistance Network (NARS-Net) annually generates the Annual AMR Surveillance Report. Currently, NARS-Net is being expanded in a phased manner to all states and UT and generates geographically representative data. AMR surveillance under NARS-Net includes standardized collection, analysis, and compilation of AMR data from all the network sites. The compiled data is used to generate the annual National AMR surveillance report, shared with National and state stakeholders, and made available in the public domain[3]. Considering the challenges in testing methodology and quality and standardization issues with automated AST systems for Vancomycin-resistant *S. aureus* and colistin-resistant gram-negative bacteria, only the isolates confirmed at the AMR-NRL at CBDDR NCDC have been included in this report. Segregated uniquely deidentified AST isolate data from the Surveillance network for six WHO priority pathogens, namely *S. aureus*, *E.coli*, *Klebsiella* species, *Salmonella* Typhi/ ParaTyphi, and *Acinetobacter baumannii*, are also submitted annually to WHO's Global AMR Surveillance System (GLASS).

This report with the reporting period from 01 January to 31 December 2022 includes aggregated data from 36 sentinel sites from 27 states/UTs. Compared with the previous year's National AMR surveillance annual report, the number of sites submitting data has increased from 35 sites to 36 sites this year. Quality of AMR surveillance data submitted by sites is ensured via continual capacity-building 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 sentinel sites performing colistin BMD and vancomycin BMD has gradually increased over the past years. The virtual capacity-building program initiated via the ECHO platform in 2020 to strengthen bacteriology testing methods at

the laboratories across the network sites has supported in establishing standardized testing across the network.

A customized VBA tool provides quarterly AMR data feedback to network sites. Network sentinel sites have improved reporting the demographic details and AST panel compliance compared to the previous years. All network sites are enrolled in one of the EQAS programs and have also taken measures to adopt stringent internal quality control of antibiotic discs, biochemicals, and culture media.

Specific limitations that could affect data quality are availability of lab information system in many of the network sites, strict adherence to internal quality control SoPs, continuous supply of all antibiotic disks as per programme SoPs and quality management systems in place for automated ID and AST systems as recommended by the manufacturer..

Over the past four years, number of isolates reported has gradually increased from 25,833 to 1,19,686. Similar to the previous five years, *Escherichia coli* (33%) remained the most commonly isolated pathogen in the AMR Surveillance data 2022. Most isolates were isolated from urine samples (43%) and among the urinary isolates, *E. coli* was the most commonly isolated priority pathogen. *S. aureus* was the most commonly isolated pathogen from Pus aspirates (28%) and blood (27%) and these findings also corroborated with the previous year's reports. Concerning location type, more than half of the priority pathogens (56%) were isolated from inpatient wards, wherein *E. coli* was the most commonly isolated pathogen from Inpatients (31%), Outpatients (42%), and Emergency settings (32%) which also corroborated with the previous year findings.

A significantly decreasing proportion of Methicillin-resistant *S. aureus* (MRSA) in blood was observed this year (59%) compared to the previous years since 2018. Likewise, a rise in the proportion of Vancomycin-resistant *Enterococcus* spp. isolated from blood culture was observed.

Trend analysis for ESBL-producing blood isolates of *E. coli* showed a significant decrease in the proportion of ESBL producing *E. coli* isolates from 2018 (86%) to 2022 (76%). This decrease might be due to improved internal and external quality management systems mandated at all network sites under the programme and more representative data now coming from different geographies of India. At the initial phase, surveillance included data majorly from Delhi and

other centres in big cities and referral hospitals. About 35% of *E. coli* and 47% of *Klebsiella* spp. were resistant to carbapenem, similar to the previous year's findings (33% and 50%, respectively).

Currently, resistance to the reserve group of antibiotics has been increasing, posing a threat as no new newer drugs are in the pipeline. Strengthening local infection prevention and antimicrobial stewardship practices at healthcare facilities in the country and addressing the drivers of AMR requires an urgent multisectoral multipronged strategy to combat AMR.

To conclude, the annual National AMR Surveillance Report generated by NARS-Net 2023 provides critical insights into India's evolving antimicrobial resistance trends for selected bacterial pathogens. Expanding the network to all states and Union Territories, along with continuous capacity building and quality assurance efforts, has improved the coverage and reliability of the surveillance data. It is essential to leverage these findings to inform evidence-based interventions, policies, and programs that will mitigate the threat of AMR and preserve the effectiveness of antibiotics in India's healthcare system.

VI. List of NARS-Net sites that contributed AMR data for the 2023 AMR Surveillance report

1. Lady Hardinge Medical College and Associated hospitals, Delhi
2. Vardhman Mahavir Medical college and SJ Hospital, Delhi
3. SMS medical College, Jaipur, Rajasthan
4. BJ Medical College, Ahmedabad, Gujarat
5. BJ Medical college, Pune, Maharashtra
6. Government Medical college, Chandigarh
7. Mysore Medical college, Mysuru, Karnataka
8. GSVM Medical College, Kanpur, Uttar Pradesh
9. Gauhati Medical College and Hospital, Guwahati, Assam
10. KAP V. Government Medical College, Tiruchirappalli, Tamil Nadu
11. NEIGRIHMS, Shillong, Meghalaya
12. Govt. Medical College, Thiruvananthapuram, Kerala
13. MGM College and Hospital, Indore, Madhya Pradesh
14. IGMC, Shimla, Himachal Pradesh
15. Govt. Medical College and Hospital, Aurangabad, Maharashtra
16. Osmania Medical College, Hyderabad, Telangana
17. Govt. Medical College & Hospital, Jammu, Jammu and Kashmir
18. Agartala Govt. Medical College, Agartala, Tripura
19. Guntur Medical College, Guntur, Andhra Pradesh
20. SCB Medical College & Hospital, Cuttack, Odisha
21. Pt. Jawaharlal Nehru Memorial Medical College, Raipur, Chhattisgarh
22. Rajendra Institute of Medical Sciences, Ranchi, Jharkhand
23. Pandit Bhagwat Dayal Sharma, Post Graduate Institute of Medical Sciences (PGIMS) Rohtak, Haryana
24. Indira Gandhi Institute of Medical Sciences, Sheikpura, Patna, Bihar
25. Govt. Medical College, Haldwani, Uttarakhand
26. Gandhi Medical College, Bhopal, Madhya Pradesh
27. Calcutta School of Tropical Medicine, Kolkata, West Bengal
28. Lala Lajpat Rai Memorial (LLRM) Medical College, Meerut, Uttar Pradesh
29. GMERS Medical College and Civil Hospital, Valsad, Gujarat
30. Coimbatore Medical College & Hospital, Coimbatore, Tamil Nadu
31. Karnataka Institute of Medical Sciences (KIMS), Hubli, Karnataka
32. Indira Gandhi Medical College & Research Institute (IGMC & RI) Puducherry
33. NAMO Medical Education and Research Institute (MERI), Silvassa, Dadra & Nagar Haveli
34. Maulana Azad Medical College (MAMC) and Associated Hospitals, Delhi
35. Sardar Patel Medical College (SPMC) and Hospital, Bikaner, Rajasthan
36. Goa Medical College & Hospital, Bambolim