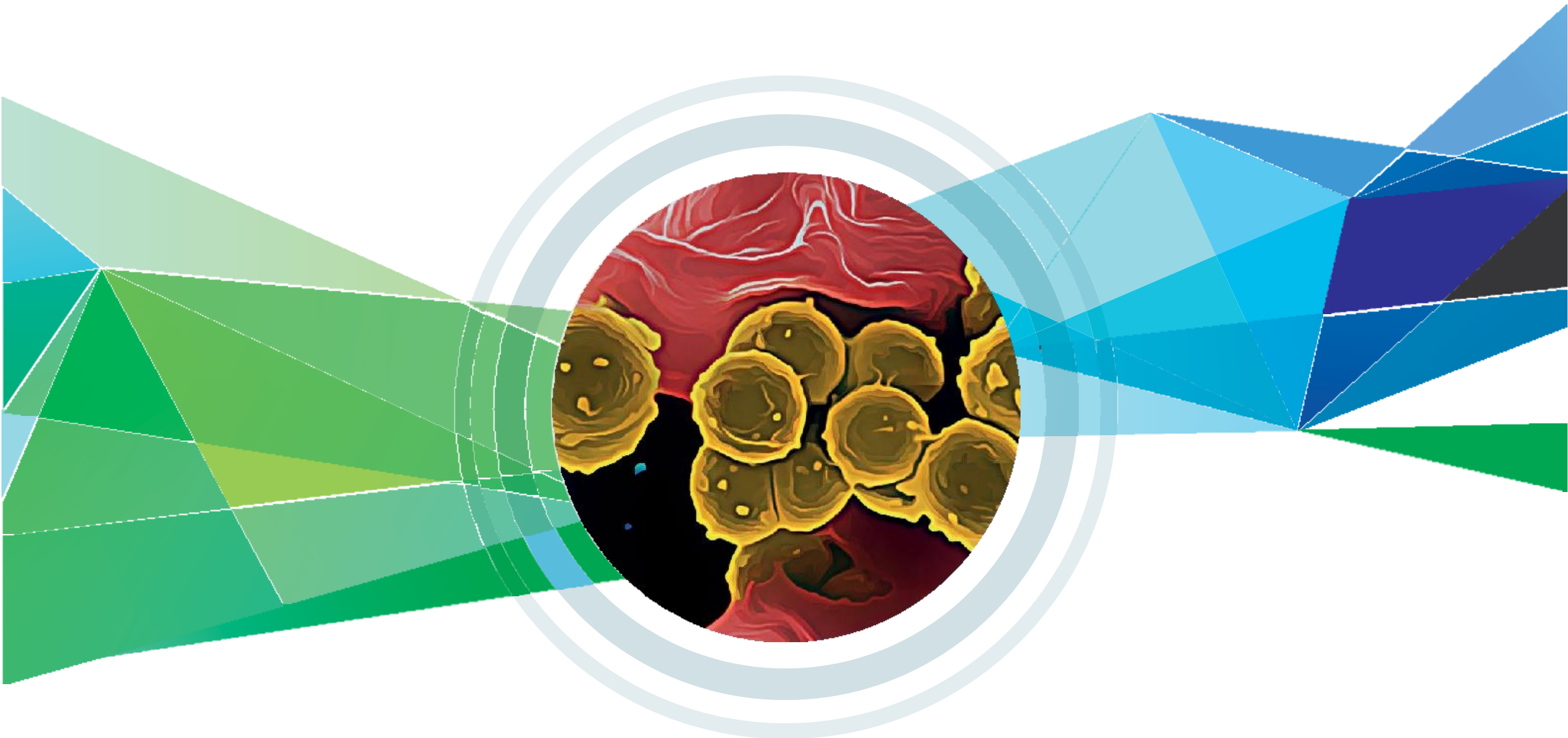
Government of Pakistan
Ministry of National Health Services, Regulations & Coordination

National Institute of Health
Government of Pakistan



National Antimicrobial Resistance (AMR) Surveillance Report Pakistan

2021-2022

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Pakistan

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Contents

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Abbreviations & Acronyms

Abbreviation	Full forms	Abbreviation	Full forms
%I	Percent intermediate	%MDR	Percent multidrug-resistant
%R	Percent resistant	%S	Percent susceptible
AMR	Antimicrobial resistance	API	Analytical Profile Index
AST	Antimicrobial susceptibility test	ATCC	American Type Culture Collection
CLSI	Clinical and Laboratory Standards Institute	LIMS	Laboratory information Management
ESBL	Extended spectrum beta- lactamase	E. coli	*Escherichia coli*
E. faecalis	*Enterococcus faecalis*	E. faecium	*Enterococcus faecium*
HIMS	Hospital information Management system	GLASS	Global AMR Surveillance System (WHO)
EQAS	External quality assurance system	HIS	Hospital Information System
K. pneumoniae	*Klebsiella pneumoniae*	CSF	Cerebrospinal fluid
MDR	Multidrug resistance	MIC	Minimal inhibitory concentration
MSSA	Methicillin- (oxacillin-) susceptible Staph. aureus	REQAS	Regional External Quality Assurance Services (Muscat)
N. gonorrhoeae	*Neisseria gonorrhoeae*	NA	Not applicable
NRL	National Reference Lab	N	Number
PDR	Pandrug-resistant	P. aeruginosa	*Pseudomonas aeruginosa*
Resp.	Respiratory	MRSA	Methicillin- (oxacillin-) resistant
S. pneumoniae	*Streptococcus pneumoniae*	S./Staph. aureus	*Staphylococcus aureus*
VRE	Vancomycin-resistant Enterococci	sp.. spp.	Species
XDR	Extensively drug resistant	WHO	World Health Organization

Abbrv.	Antibiotics	Abbrv.	Antibiotics	Abbrv.	Antibiotics
AMC	Amoxicillin-clavulanic acid	**FCT**	5-Fluorocytosine	**NOR**	Norfloxacin
AMK	Amikacin	**FEP**	Cefepime	**OXA**	Oxacillin
AMP	Ampicillin	**FLU**	Fluconazole	**PEN**	Penicillin G
ATM	Aztreonam	**FOS**	Fosfomycin	**TOB**	Tobramycin
AZM	Azithromycin	**FOX**	Cefoxitin	**TZP**	Piperacillin-tazobactam
CAZ	Ceftazidime	**FQ**	Fluoroquinolones	**VAN**	Vancomycin
CIP	Ciprofloxacin	**GEH**	Gentamicin	**RIF**	Rifampin, rifampicin
CLI	Clindamycin	**GEN**	Gentamicin	**SAM**	Ampicillin-sulbactam
CLR	Clarithromycin	**IPM**	Imipenem	**STH**	Streptomycin
CRO	Ceftriaxone	**LNZ**	Linezolid	**SXT**	Trimethoprim-sulfamethoxazole
CTX	Cefotaxime	**LVX**	Levofloxacin	**TCC**	Ticarcillin-clavulanic acid
CXM	Cefuroxime	**MEM**	Meropenem	**TCY**	Tetracycline
CZO	Cefazolin	**MFX**	Moxifloxacin	**TGC**	Tigecycline
DAP	Daptomycin	**MNO**	Minocycline	**TEC**	Teicoplanin
ERY	Erythromycin	**MUP**	Mupirocin		
ETP	Ertapenem	**NIT**	Nitrofurantoin		

Foreword

In 2017, NIH has established National AMR Surveillance system under the leadership and supervision of Ministry of National Health Services Regulation and Coordination (MoNHSR&C) Government of Pakistan. Provincial governments engaged in AMR surveillance through nomination of AMR focal persons and establishment of steering committees at ministerial level.

Pakistan enrolled in GLASS (2016) and progressively worked to develop Pakistan AMR surveillance system in 2018. Initially, National AMR Surveillance started to work with five lab based sentinel sites and up until now is expanded to 26 sites. AMR surveillance data from all sentinel sites of respective provinces is reported to National Coordination Center (NCC). This system constitutes of hospitals, health facilities and laboratories at provincial and federal level and integrated with the global components GLASS as well. Moreover, laboratory specimens are routinely collected and tested for priority pathogens.

The surveillance system involves strong commitment from participating laboratories and close collaboration with AMR sentinel lab networks. It also involves the increase in enrollments and active participation of laboratory network in national surveillance system to monitor AMR. It will also reflect a collective understanding and engagement to support the global effort to control AMR. The support given by World Health Organization (WHO) Regional & Country Office, WHO Collaborating Centers, Fleming Funds Country Grants/Development Alternatives Incorporation (DAI) and other international partners have pivotal role in meeting the expectations of GAP and GLASS.

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1. Executive summary

Antimicrobial resistance (AMR) represents a major threat to human health, with significant global economic and security implications. Surveillance is an essential tool to inform policies and infection prevention and control responses. Importantly, it is the cornerstone for assessing the spread of AMR and for informing and monitoring the impact of local, national, and global strategies. The NIH, as a focal point for AMR, has established the AMR surveillance system with a commitment to support the second objective of the National Action Plan-AMR initiative: to "strengthen knowledge through surveillance and research" and to continue filling knowledge gaps to inform strategies at all levels.

AMR surveillance is a laboratory-based system in which enrolled sentinel clinical laboratories share data with the NIH on an annual basis in the prescribed format. AMR data are collected through a case-finding surveillance system, which collates results of microbiological testing done routinely in laboratories for clinical purposes. This report summarizes AMR data for the years 2021 and 2022. During the data call years 2021 and 2022, 19 and 26 laboratories submitted AMR data, respectively.

For the reporting period of January-December 2021, a total of 132,269 non-duplicate isolates from 19 surveillance sites/laboratories were received for analysis. The most frequently reported pathogens were *E. coli* (35%), followed by *S. aureus* (13%), *K. pneumoniae* (9%), and *P. aeruginosa* (3%). During the reported year, data showed a high burden of resistance among priority pathogens and antibiotics; for instance, *Escherichia coli* exhibited resistance rates of 72% to Cefotaxime, 75% to Ceftriaxone, and 72% to Ceftazidime. *Acinetobacter species* showed carbapenem resistance of 74%, and methicillin-resistant *Staphylococcus aureus* (MRSA) was reported at 68%. Moreover, among *Enterobacteriaceae*, over 52% of reported E. coli and *Klebsiella pneumoniae* isolates were Multi-drug-resistant (MDR), and 3.6% and 8.7% were possibly Pan Drug Resistant (PDR), respectively. Furthermore, among the reported isolates of *Salmonella Typhi*, 38% were Extensively Drug Resistant (XDR), and more than 71% were resistant to ceftriaxone.

Similarly, during the reporting period of 2022, a total of 229,617 non-duplicate isolates from 26 surveillance sites/laboratories were received and available for analysis. The most frequently reported pathogens were *E. coli* (36%), followed by *K. pneumoniae* (12%), *S. aureus* (10%), and *P. aeruginosa* (7%). During the reported year 2022, data showed a high burden of resistance among priority pathogens and antibiotics; for instance, *Escherichia coli* exhibited resistance rates of 77% to Cefotaxime, 75% to Ceftriaxone, and 74% to Ceftazidime. Carbapenem resistance among *Acinetobacter species* was reported at 73%, and MRSA was reported at 65%. Moreover, among *Enterobacteriaceae*, over 51% of reported *E. coli* and *Klebsiella pneumoniae* isolates were MDR, and 2.1% and 6.7% were possibly PDR, respectively. Furthermore, among the reported isolates of *Salmonella Typhi*, 38% were XDR, and more than 72% were resistant to ceftriaxone.

2. Introduction

The grave concern of Antimicrobial Resistance (AMR) cannot be overstated, as it stands as a foremost and priority health problem worldwide, particularly in Low- and Middle-Income countries, including Pakistan. The Government of Pakistan is committed to addressing AMR issues by endorsing the AMR Global Action Plan approved at the 68th session of the World Health Assembly in 2015 and making concerted efforts to tackle this problem by implementing the National Action Plan for AMR.

The burden of antibiotic resistance (AMR) among bacteria, primarily driven by the consumption of antimicrobials, has steadily increased and is now recognized as a major health crisis. Prior to antibiotic use, a low level of AMR was observed, primarily due to the selective pressure of antibiotic exposure, not only in humans but also in the animal health sector. The progressive rise in AMR has become a global public health concern. It is estimated that bacterial AMR was directly responsible for 1.27 million global deaths in 2019 and contributed to 4.95 million deaths.[1] In addition to death and disability, AMR has significant economic costs. The World Bank estimates that AMR could result in an additional US$1 trillion in healthcare costs by 2050, and US$1 trillion to US$3.4 trillion in gross domestic product (GDP) losses per year by 2030.[2]

In 2014, the World Health Organization (WHO), in collaboration with member states, generated a global report on AMR surveillance, providing a comprehensive overview of the magnitude and current surveillance status of AMR worldwide.

In 2020, there was an increase of more than 15% compared to 2017 in antimicrobial resistance (AMR) rates for meropenem and third-generation cephalosporin resistance in bloodstream *E. coli* infections, ciprofloxacin resistance in *Salmonella spp.* bloodstream infections, and azithromycin resistance in gonorrhea. These increases raise significant concerns, particularly in the context of the AMR indicators monitored under the Sustainable Development Goals (SDG) framework. Across 76 countries, median reported rates reached 42% for third-generation cephalosporin-resistant *E. coli* and 35% for methicillin-resistant *Staphylococcus aureus,* highlighting the urgency of addressing antimicrobial resistance.[3]

Antimicrobial resistance (AMR) has alarmingly increased across the globe, and Pakistan is no exception. The significant burden of multi and pan-resistance bacterial infections leads to considerable mortality and morbidity, limiting our options for treating infectious diseases. Notably, there has been a significant increase in *S. Typhi ceftriaxone* resistance, rising from 60% in 2019 to 79% in 2021. Methicillin resistance was reported in 65% of *S. aureus* isolates in 2021. In *Acinetobacter baumannii*, resistance against Carbapenems reached up to 70% in 2021, as indicated in National AMR data. Additionally, there is an ever-increasing trend of ESBLs, NDMs, VREs, CREs, MDR TB, XDR TB, and MDR *Candida auris*.[4]

In fulfillment of the commitment to contain AMR in the country, Pakistan has developed a National Action Plan (NAP).[5] This plan was completed in collaboration with the WHO and involved all stakeholders at the federal, provincial, and regional levels. It is built upon the objectives of the Global Action Plan (GAP) and the National Strategic Framework, developed through a systematic, all-inclusive consultative process to ensure the ownership, agreement, and commitment of all stakeholders.

1 Antimicrobial Resistance Collaborators. (2022). Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet; 399(10325): P629-655. DOI: https://doi.org/10.1016/S0140-6736(21)02724-0

2 Drug-Resistant Infections: A Threat to Our Economic future (March 2027) https://www.worldbank.org/en/topic/health/publication/drug-resistant-infections-a-threat-to-our-economic-future

3 Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report 2022. https://iris.who.int/bitstream/handle/10665/364996/9789240062702-eng.pdf?sequence=1

4 Pakistan Antimicrobial Resistance Surveillance System Surveillance Report 2017-2019. https://www.nih.org.pk/wp-content/uploads/2020/03/Report_2017-2018-NIH-Final.pdf

5 Antimicrobial Resistance National Action Plan Pakistan. https://www.nih.org.pk/wp-content/uploads/2018/08/AMR-National-Action-Plan-Pakistan.pdf

The National Action Plan on AMR provides a roadmap to establish a functional, coordinated, collaborative, and sustainable AMR containment system using a “One Health” approach aligned with the WHO Global Action Plan on AMR. The action plan has seven strategic priorities as follows:

i. Development and implementation of a national awareness-raising and behavioral change strategy on antimicrobial resistance
ii. Establishment of an integrated national AMR surveillance system (human, animal usage, and resistance monitoring)
iii. Improve prevention & control of infections in health care, community, animal health, food, agriculture, and environment
iv. Update and enforce regulations for human and veterinary antimicrobial utilization
v. Phase out the use of antimicrobials as Growth Promoters and provide appropriate alternatives (such as prebiotics, probiotics)
vi. Integration of AMR in all public health research agendas, including research on vaccines
vii. Estimation of the health and economic burden of AMR for decision making.

The second strategic objective entails strengthening knowledge and generating evidence through surveillance and research. This report underscores the objectives, key components, and achievements of the surveillance system, emphasizing the importance of collaborative efforts in combating AMR in the country.

2.1 Antimicrobial Resistance Surveillance:

The AMR Surveillance System aims to estimate the burden of AMR in priority pathogens and provide valuable information for informed decision-making and interventions to address this public health challenge. The WHO Global Antimicrobial Resistance and use Surveillance System (GLASS) was launched in 2015 to foster surveillance of antimicrobial resistance (AMR) and antimicrobial consumption and use (AMC/U) globally, informing strategies to contain AMR. GLASS monitors progress in the implementation of national surveillance systems worldwide to ensure standardized collection, analysis, and sharing of official data on AMR among priority pathogens and antimicrobial consumption (AMC), as well as information on key AMR epidemiological indicators. Since its launch, GLASS has expanded its scope and coverage. As of May 2021, a total of 109 countries and territories worldwide have been enrolled in GLASS.[6]

Pakistan has established sentinel surveillance to determine the burden of antimicrobial resistance (AMR) in the country. This initiative aims to support the National Action Plan (NAP), particularly focusing on its second objective: strengthening knowledge through surveillance and research, and enhancing existing activities.

2.2 Pakistan AMR Surveillance System:

The Pakistan AMR Surveillance System is built upon three core components, collectively contributing to the success and sustainability of surveillance efforts (illustrated in fig 2.1): the National Coordinating Center (NCC), serving as the central coordinating body responsible for overseeing and facilitating surveillance activities. It promotes effective communication, collaboration, and coordination among stakeholders involved in the surveillance system. The National Reference Laboratory (NRL) acts as the primary reference point for comprehensive testing and analysis. Equipped with advanced technology and expertise, the NRL ensures the accuracy and validation of data collected from the sentinel sites. The AMR Surveillance Sentinel laboratories are located throughout the country, and these sentinel sites play a crucial role in data collection.

Pakistan has been included among the countries enrolled in the Global Antimicrobial Resistance Surveillance System (GLASS) since 2017, actively sharing data. Since its enrollment, the National Institute of Health (NIH) has been collaborating with surveillance sentinel laboratories. In 2017, five (05) clinical laboratories from various provinces were enrolled in the AMR surveillance system. The following year, 2018, data from nine (09) sites were submitted to WHO GLASS and analyzed by NIH. Subsequently, in 2019, 2020, and 2021, data from 12, 18, and 19 clinical microbiology laboratories, respectively, were submitted to WHO GLASS.

6 GLASS manual for antimicrobial resistance surveillance in common bacteria causing human infection. https://iris.who.int/bitstream/handle/10665/372741/9789240076600-eng.pdf?sequence=1

2.3 Objectives:

1. Continual systematic collection of data from microbiology laboratories in both public and private sectors, establishing a systematic reporting and feedback mechanism, followed by dissemination of AMR surveillance reports to all stakeholders nationally and internationally.

2. Epidemiological analysis and interpretation of surveillance data to assess the burden of AMR and to formulate policies for future prevention and control.

3. Utilization of surveillance data for raising awareness and advocacy through risk communication strategies, as well as for the effective implementation of stewardship programs aimed at the responsible use of antimicrobial agents.

Laboratories at hospitals and other healthcare centers, as well as clinical microbiology laboratories (both public and private), are generating and collecting clinical and antimicrobial resistance (AMR) data as part of their routine patient care. This data can also be utilized for generating cumulative antibiograms and for local monitoring of antimicrobial resistance at the facility level, as well as for public health surveillance of antimicrobial resistance at the country level.

2.4 Identification and selection of surveillance sites and labs:

Surveillance sites/laboratories included in this report are identified based on the following criteria:

i. Having established microbiology diagnostic capacity,
ii. Demonstrating willingness to participate and share AMR data,
iii. Agreeing to participate in laboratory assessments through standard evaluation tools,
iv. Engaging in external quality assurance programs such as NEQAS (National External Quality Assurance Scheme) or any other EQA programs
v. Achieving a minimum performance score of at least 80% in other relevant international EQA programs,
vi. Maintaining a functional laboratory information management system (LIMS),
vii. Adhering to data reporting mechanisms.

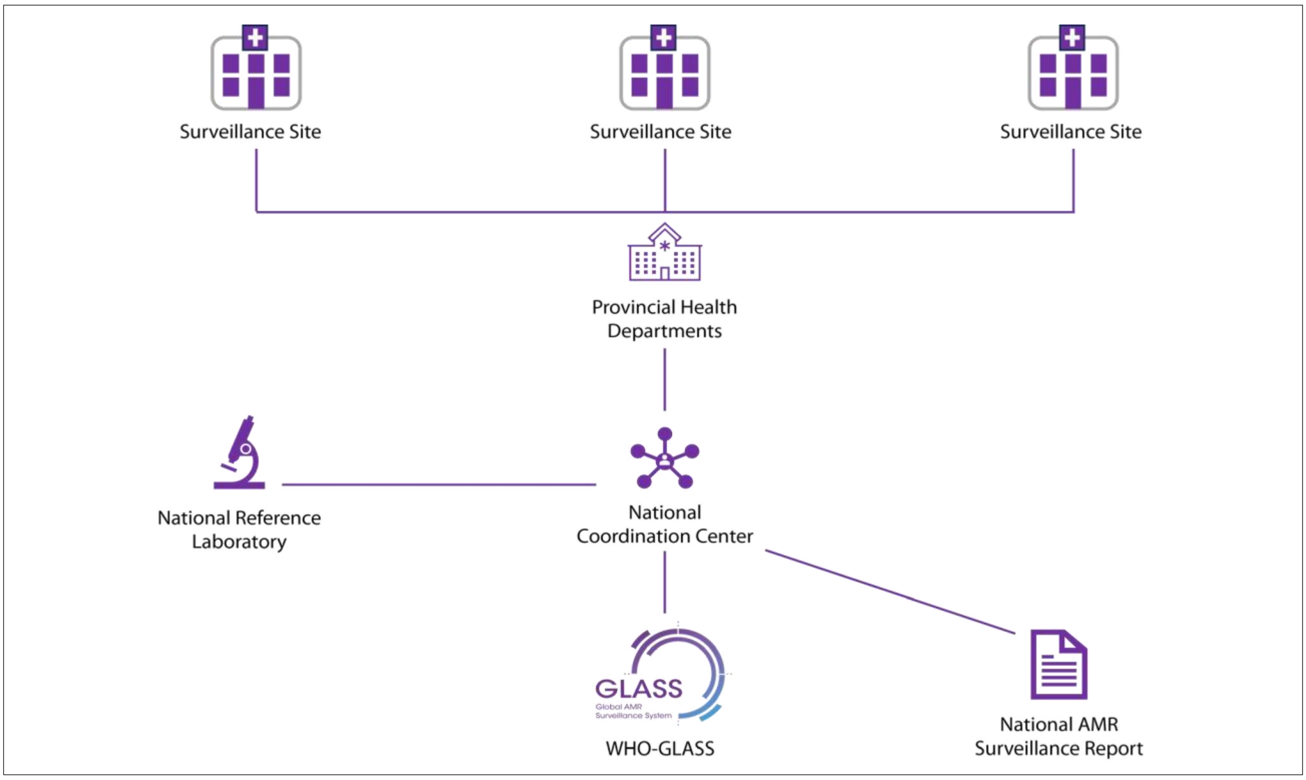


Figure 2.1: Components of National AMR surveillance system

2.5 Identification of organisms and Antimicrobial Susceptibility Testing:

Participating microbiology laboratories use either a manual bio-chemical testing or API (Analitical profile index)/ commercial automated systems for identificartion of bacteria. For routine antimicrobial susceptibility testing, sentinel sites using either diffusion method or automated systems following CLSI or EUCAST guidelines are prefered to enrolled.

2.6 Data collection Mechanism:

Nominated focal points at participating surveillance sites submit AMR data on a quarterly or annual basis to the NCC at NIH. The submitted AMR data includes microbiology data, and where available and technically feasible, clinical and demographic data. Clinical and demographic data for each isolate are extracted from hospital/laboratory information systems (HIS/LIS) and shared with the NCC in the prescribed format through email. The data variables, such as the patient's date of birth/age, gender, nationality, location, location type, clinical specialty/ department, date of admission/discharge, etc., are collected. Laboratories share isolate-based data of positive cultures where information on the patient population with laboratory-confirmed infections (positive cultures) caused by the defined target pathogens.

Currently, following the GLASS protocol, blood, urine, feces (stool), and urethral and cervical swabs are designated as priority specimen types, with eight priority pathogens included for global AMR surveillance and reporting (list attached as (Annexure I). To capture the resistance profile for other pathogens, the Pakistan AMR surveillance system also collects data for these pathogens and specimen types.

2.7 Data Cleaning:

After submission of AMR data to the national AMR Surveillance Coordination Center, the raw data is initially checked and cleaned for plausibility, quality, and completeness. Feedback is then communicated to the AMR focal point at the surveillance site as required. AMR focal points approached to verify, update and resubmit the data as applicable. After the initial cleaning of AMR raw data, it is further converted to WHONET format using the BacLink tool. The following data is excluded from analysis, if technically possible:

i. Internal quality control isolates (e.g., weekly ATCC QC strains)
ii. External quality control isolates (EQAS, i.e., NEQAS, CAP, REQAS)
iii. Isolates labeled as 'screening,' 'validation,' 'verification,' 'proficiency testing,' or similar
iv. Duplicate isolates (copy strains); only the first isolate per patient, specimen type, and species during the reporting period (one year) is included
v. Isolates from primarily contaminated specimen types
vi. Other non-diagnostic isolates (e.g., from environmental sampling, infection control, OT/ICU surveillance)
vii. Species for which less than 10 isolates are available for analysis
viii. Antimicrobial agents that are selectively/ not routinely tested (i.e., less than 70% of isolates were tested)

As recommended by CLSI guideline M39-Ed5:2022 and the WHO GLASS protocol, multiple isolates (copy strains) are routinely excluded from the analysis. This involves considering only the first isolate with antibiotic results of a given species per patient, specimen type, and analysis period (e.g., one year), irrespective of body site, antimicrobial susceptibility profile, or other phenotypical characteristics (e.g., biotype).

2.8 Data Analysis:

Data analysis is performed using the WHONET 2022 Software for Antimicrobial Resistance Surveillance (WHONET, 2022). Descriptive analysis involves calculating frequencies and presenting them in the form of graphs, charts, and tables. For analysis, the qualitative susceptibility categories - S (susceptible), I (intermediate), and R (resistant) - are utilized, as reported by the laboratory. The antibiotics and resistence data presented in this report are significant for antimicrobial resistance surveillance purposes only. They may or may not be first-line options for susceptibility testing or patient treatment guidelines and should not be interpreted as such.

2.9 Methodology:

» Data Collection:

Year 2021: In the first week of July 2022, a data call was issued to thirty-three (n=33) laboratories, requesting to share AMR data from January to December 2021. Formal letters were dispatched from AMR national focal points to the laboratory focal persons. For the year 2021, a total of ninteen (19) public and private healthcare facilities/clinical laboratories submitted data. Among these, 09 were public sector hospital laboratories, and 10 were private sector facilities (comprising 07 hospitals and 03 clinical laboratories). A list of the sentinel sites, along with their affiliations, is provided in (Annexure II).

Year 2022: In the year 2022, a data call was issued via formal letters to 31 sentinel laboratories during the first week of July 2023, requesting data from January to December 2022. Reminders were sent to prompt data submission by the end of July 2023. Out of these, 26 sentinel sites shared the data in the prescribed format. Among the 26 sites, a total of 12 were public-sector hospital laboratories, while 14 were from the private sector, comprising 10 hospital laboratories and 4 clinical laboratories. A list of the sentinel sites, along with their affiliations, is provided in (Annexure III).

» Data Cleaning and Analysis:

The data was submitted in the form of Excel sheets in the predefined format. After the submission of AMR data to the National AMR Surveillance Coordination Center, the raw data were checked and cleaned for plausibility, quality, and completeness. Data from five (05) sentinel laboratories were not in accordance with the prescribed format, and feedback was communicated to the AMR focal point at the surveillance sites of the respective laboratories to resubmit the data. Updated data was received from laboratories, which were included in the analysis. Therefore, data from nineteen (19) sentinel sites for year 2021 and (26) sentinel sites for 2022 were available for further processing and analysis. After the initial cleaning of AMR raw data, it was converted to WHONET format using the BacLink software, and one national dataset file was created after removing the patient's identifier and names of individual laboratories. An aggregated WHONET data file of eight priority pathogens and four specimen types (the list is attached as an annex) was submitted to the WHO GLASS platform. For the purpose of this report, the data were analyzed using WHONET and SPSS software. Data analysis was performed for each priority pathogen with respect to distributions of isolates/patients by isolate type, gender, age category, and antimicrobial susceptibility profile (S, I, R). Antimicrobial susceptibility testing results are presented as the proportion of isolates of a specific microorganism that are susceptible (S), intermediate (I), and resistant (R) to a specific antimicrobial agent.For example, in *E. coli*, the proportion of isolates among different specimen types was calculated, and age/gender distribution was analyzed among positive cultures of *E. coli*. The percentage of each antibiotic tested and the S-I-R profile were calculated among the total tested antibiotics for specific organisms.

» Definitions used:

- MDR (multidrug resistance) is defined as acquired non-susceptibility to at least one agent in three or more antimicrobial classes, as suggested by Magiorakos et al.[7]
- XDR/PDR: Magiorakos' et al. definitions for extensively drug-resistant (XDR) and pan drug-resistant (PDR) organisms could not be strictly applied, as only a limited number of antibiotic classes were routinely tested by clinical labs, and MDR isolates were not routinely sent to a reference lab. Therefore, the following modified definitions were used for 'possible XDR' and 'possible PDR' isolates.
- 'Possible XDR': Non-susceptibility to at least one agent routinely tested by clinical labs in all but two or fewer antimicrobial categories (i.e., bacterial isolates remain susceptible to only one or two categories).
- 'Possible PDR': Non-susceptibility to all agents routinely tested by clinical labs in all antimicrobial categories (i.e., no agents tested as susceptible for that organism).

7 https://pubmed.ncbi.nlm.nih.gov/21793988/

3. Demographic and Sensitivity pattern of Priority Pathogens during 2021

For the reporting period of January-December 2021, a total of 132,269 non-duplicate isolates from 19 surveillance sites/laboratories were available for analysis. The most frequently reported pathogens were *E. coli* (44%), followed by *S. aureus* (16%), *K. pneumoniae* (12%), and *P. aeruginosa & Acinetobacter sp.* (4%).

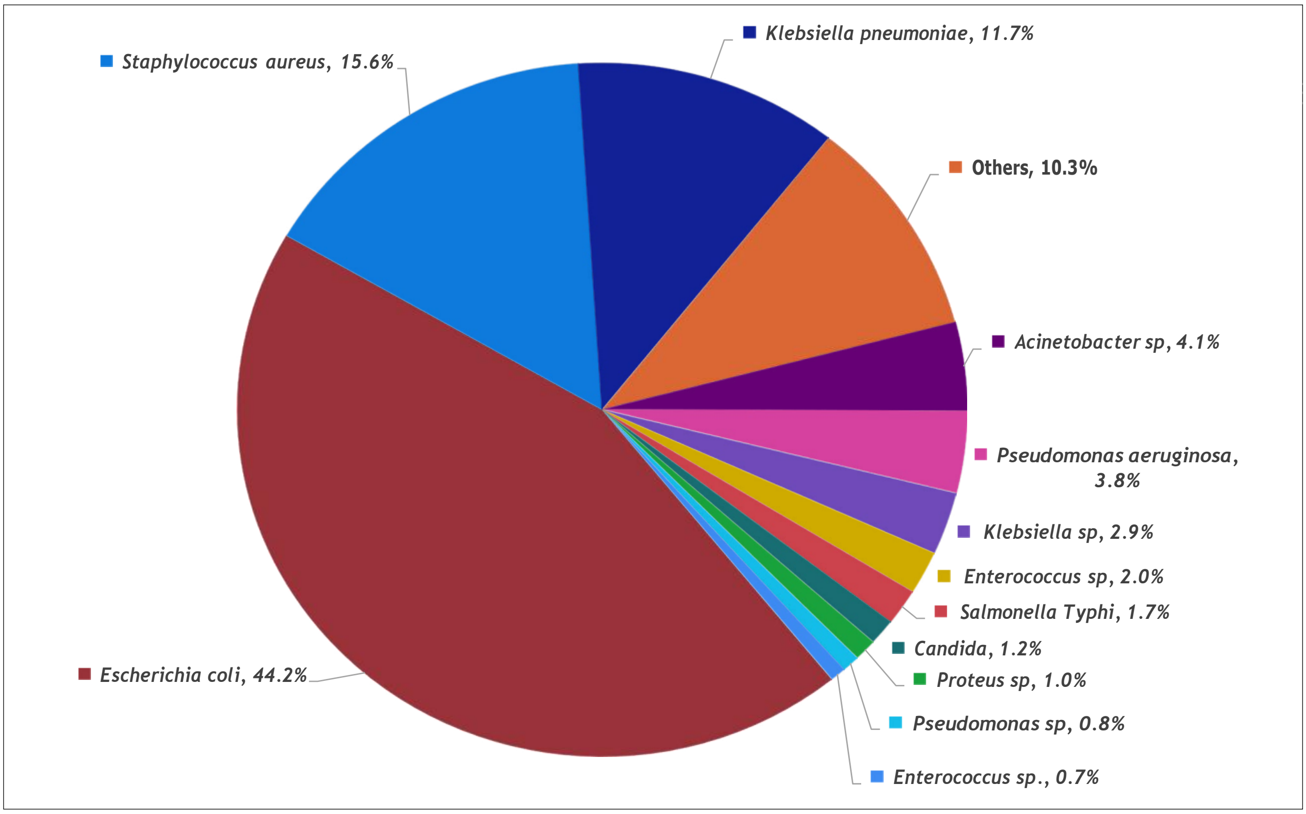


Figure 3.0: Distribution of AMR priority pathogens 2021(n= 132,269)

3.1 Escherichia coli:

In the year 2021, a total of 19 sentinel sites reported 58,457 isolates of *E. coli*. The reported data indicates a typical trend, with the bacteria being more prevalent in urine specimens, accounting for 70% (n=40,935) of the total isolates and 38,500 (66%) in female patients. This higher prevalence in urine samples is attributed to the increased prevalence of urinary tract infections in female patients. Additionally, in terms of age distribution, *E. coli* infections were more common in the older age group (>25 years), comprising 50,271 of the reported cases, especially in the age group of 55-74 years.

Among these, the most tested and reported antimicrobials are Ciprofloxacin (56,215; 96%), Trimethoprim-Sulfamethoxazole (50,595; 87%), Ceftriaxone (91%), Imipenem and Meropenem (66%), Amikacin (63%), Ampicillin (62%), and Piperacillin-Tazobactam (60%) from *E. coli* isolates across all specimen sources. Resistance to *E. coli* ranges from 90% for Ampicillin to 9% for Amikacin, based on data reported in 2021. Similarly, among cephalosporins, 80% of isolates show resistance to cefuroxime, while 75% are resistant to ceftriaxone. Resistance to nitrofurantion and fosfomycin remain 11% and 8% respectively among the urine specimen.

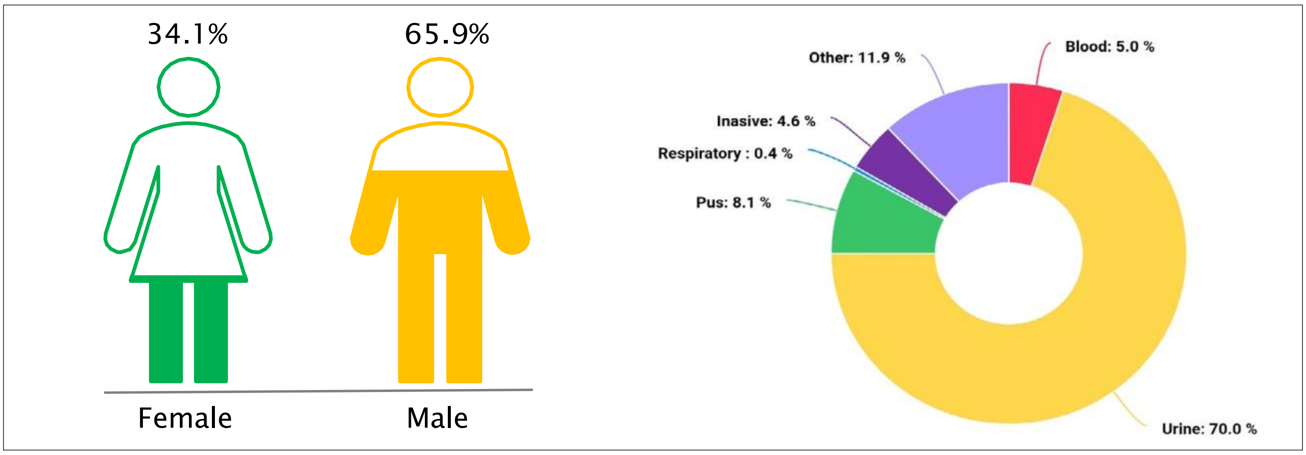


Figure 3.1: *E. coli*: proportion of isolates among different specimen types & gender wise, 2021

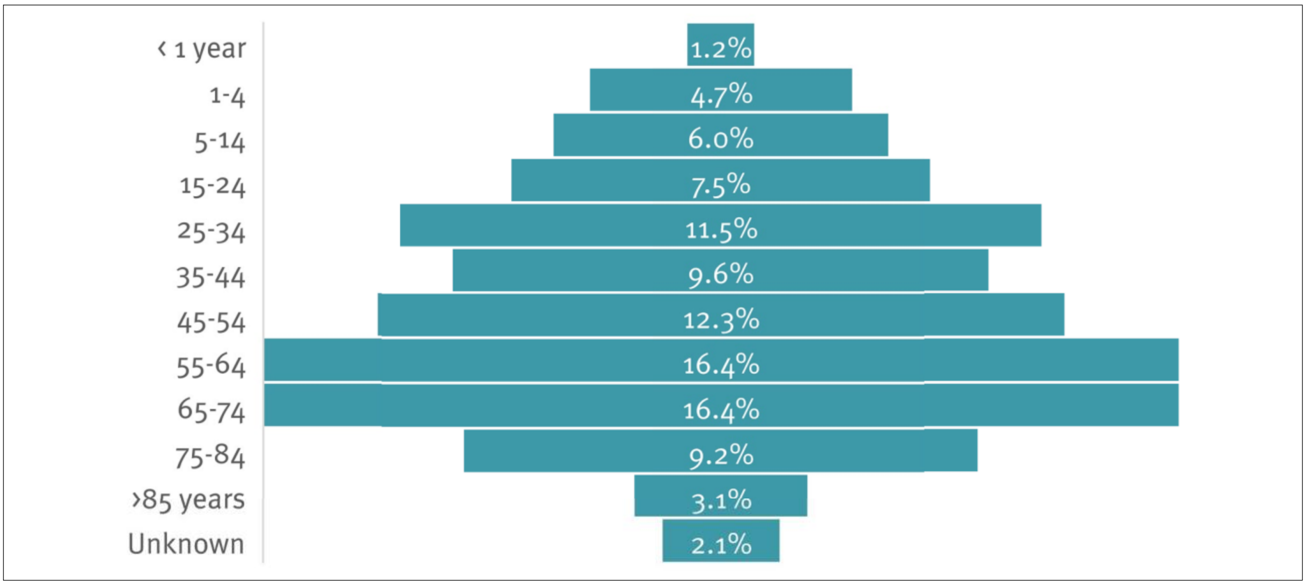


Figure 3.2: *E. coli*: Gender wise distribution, 2021

Table 3.1: Percentages of resistant, susceptible and intermediate isolates for *E. coli*, (isolates from all sources), Pakistan, 2021

E. coli (n=58,457)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	36,169	89.8	0.4	9.8
Amoxicillin-Clavulanic acid	AMC	32,255	67.6	0.9	31.5
Piperacillin-Tazobactam	TZP	34,858	20.6	1.6	77.8
Cefuroxime	CXM	15,132	80.3	0.7	19.0
Ceftazidime	CAZ	9,630	72.2	1.4	26.4
Ceftriaxone	CRO	53,311	74.7	0.2	25.1
Cefotaxime	CTX	17,893	72.4	0.2	27.4
Cefepime	FEP	10,638	70.1	1.2	28.7
Ertapenem	ETP	33,580	9.7	0.4	89.9
Imipenem	IPM	38,891	13.6	0.4	86.1
Meropenem	MEM	38,801	13.8	0.3	85.8
Amikacin	AMK	36,625	8.8	2.0	89.2
Gentamicin	GEN	31,556	30.3	0.5	69.2
Tobramycin	TOB	19,718	42.5	0.6	56.8
Ciprofloxacin	CIP	56,215	70.8	2.2	27.0
Trimethoprim-Sulfamethoxazole	SXT	50,595	68.5	0.1	31.4
Fosfomycin[a]	FOS	30,380	8.4	0.2	91.5
Nitrofurantoin[a]	NIT	30,206	11.3	1.6	87.1
Tigecycline	TGC	2,234	11.2	1.5	87.3

[a] Fosfomycin and Nitrofurantoin: Isolates from the urinary tract only.

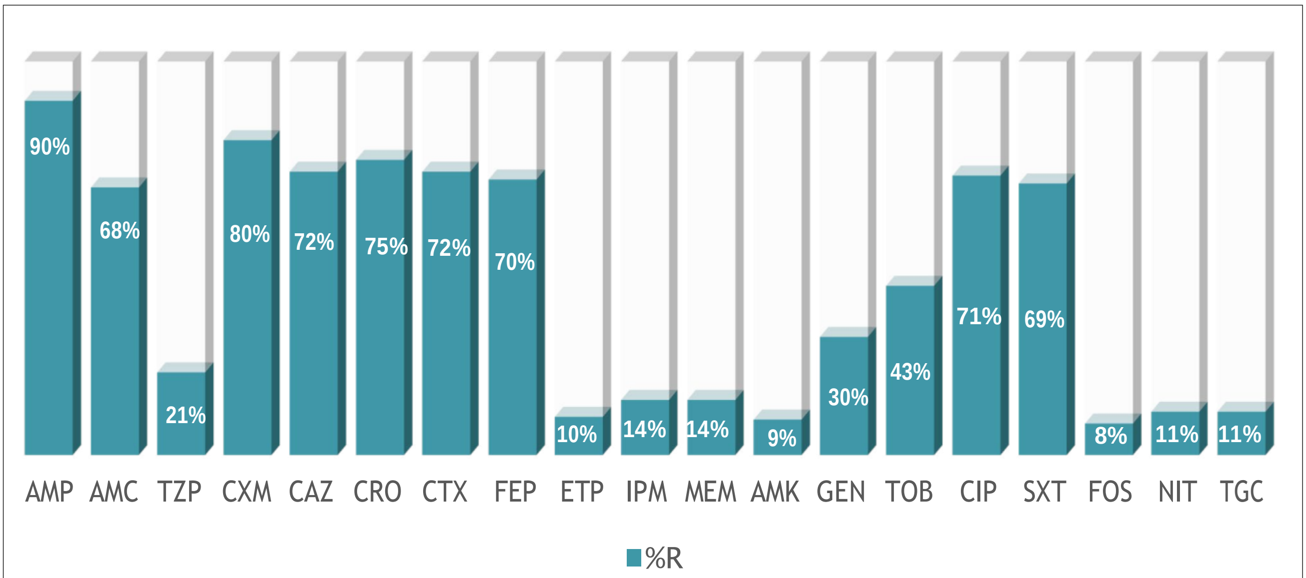


Figure 3.3: Percentages of resistant isolates for *E. coli*, (isolates from all sources), Pakistan, 2021

3.2 *Klebsiella pneumoniae:*

In 2021, a total of 19 sentinel sites reported 15,446 isolates of *Klebsiella pneumoniae*. *Klebsiella pneumoniae* is predominantly isolated from urine (49.6%, n=7,662) and is more prevalent in female patients (n=8,320), similar to *E. coli*. Likewise, it exhibits a typical age distribution, with a higher prevalence in the age group of 45-74 years (n=8,075) especially age group of 55-74 years which accounted for 30% of the reported siolates.

Among these, the most tested and reported antimicrobials are ceftriaxone (98%), ciprofloxacin (95%), trimethoprim-sulfamethoxazole (93%), and imipenem (75%), meropenem (75%) from *K. pneumoniae* isolates across all specimen sources. Resistance against *K. pneumoniae* ranged from 72% for cefotaxime to 22% for ertapenem. Fluoroquinolones (such as ciprofloxacin) exhibit a resistance rate of 53.2%. Moreover, ceftriaxone, the most frequently tested antibiotic for *K. pneumoniae* in the reported data, shows a resistance rate of 64%. Similarly, carbapenems (meropenem, imipenem and ertapenem) have demonstrated resistance of 30%, 29% and 22% respectivelly.

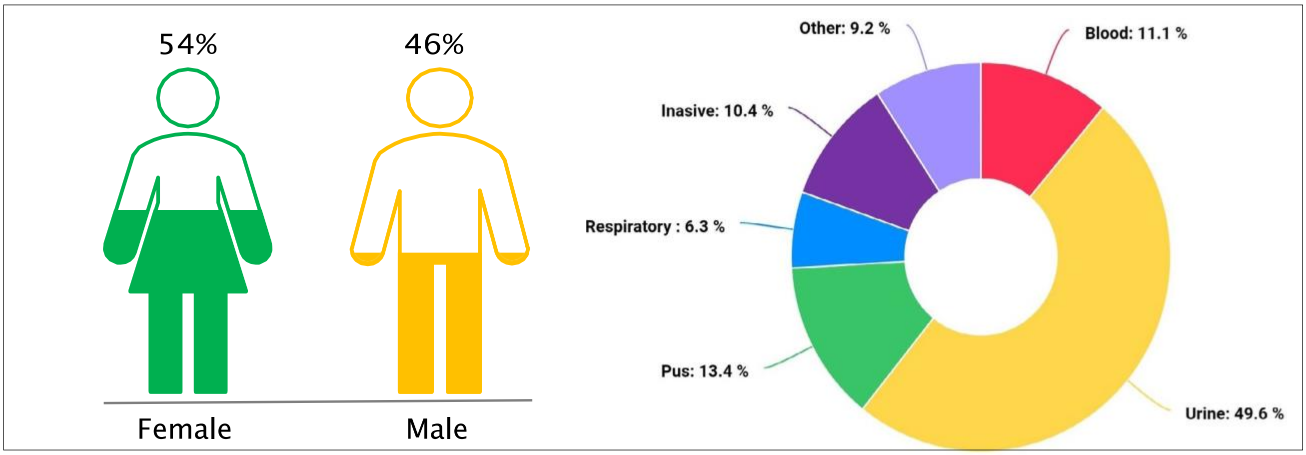


Figure 3.4: *Klebsiella pneumoniae*: proportion of isolates among different specimen types, 2021

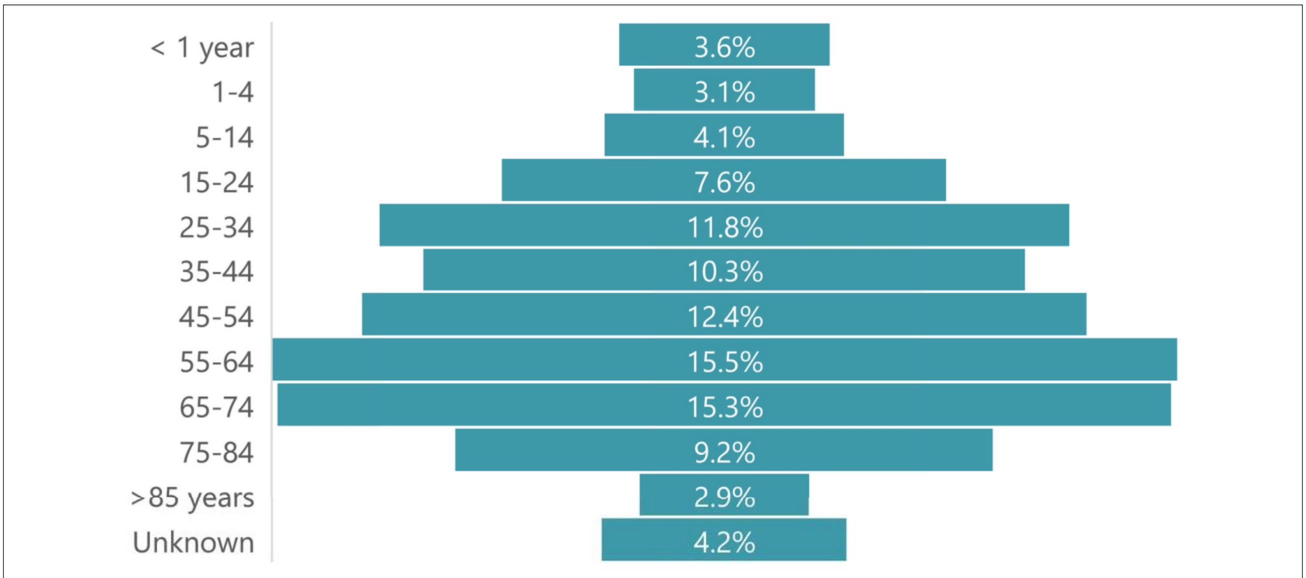


Figure 3.5: *Klebsiella pneumoniae*: Gender wise distribution, 2021

Table 3.2: Percentages of resistant, susceptible and intermediate isolates for *Klebsiella pneumoniae*, (isolates from all sources), Pakistan, 2021

Klebsiella pneumoniae (n=15,446)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Amoxicillin/Clavulanic acid	AMC	8,874	68.2	0.2	31.6
Piperacillin/Tazobactam	TZP	8,131	36.1	0.6	63.3
Cefuroxime	CXM	3,428	70.7	0.0	29.3
Ceftazidime	CAZ	1,115	63.2	0.8	36.0
Ceftriaxone	CRO	15,062	63.6	0.1	36.3
Cefotaxime	CTX	5,684	71.8	0.0	28.2
Cefepime	FEP	1,477	67.6	1.6	30.7
Ertapenem	ETP	7,863	22.0	0.2	77.8
Imipenem	IPM	11,590	29.2	0.8	69.9
Meropenem	MEM	11,087	30.3	0.5	69.3
Amikacin	AMK	9,146	23.3	0.4	76.2
Gentamicin	GEN	8,199	34.9	0.1	65.0
Tobramycin	TOB	6,373	44.9	0.2	54.9
Ciprofloxacin	CIP	14,715	53.2	3.9	43.0
Trimethopri-Sulfamethoxazole	SXT	14,402	56.0	0.2	43.8
Nitrofurantoin	NIT	5,374	27.3	1.7	71.1

[a] Nitrofurantoin: Isolates from urinary tract specimens only.

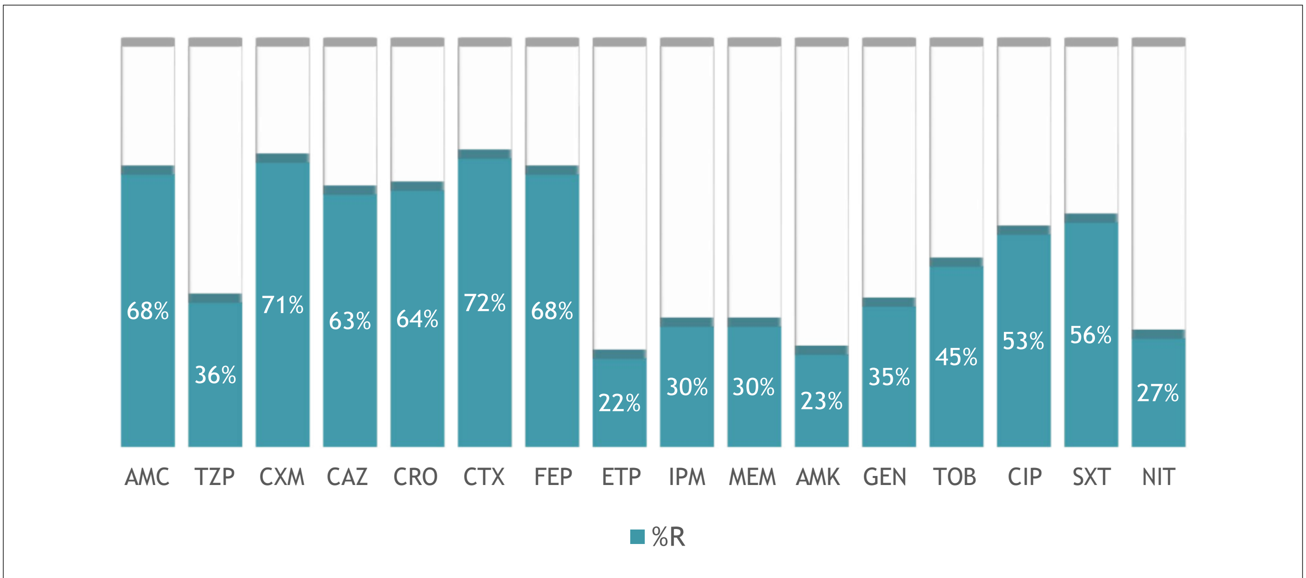


Figure 3.6: Percentages of resistant isolates for *Klebsiella pneumoniae*, isolates from all sources, Pakistan, 2021

3.3 *Salmonella* Typhi:

In 2021, a total of 19 sentinel sites reported 2,309 isolates of *Salmonella* Typhi. *Salmonella Typhi* is predominantly associated with bloodstream infections, with a higher prevalence among males (n=1,358, 58.8%) compared to females. The age-wise distribution follows the typical pattern, with typhoid infection being more common in younger age groups. Specifically, over 60% (n=1,558) of isolates were reported from the age groups of 1-14 years.

Among these antimicrobials, Ampicillin and ciprofloxacin have been the most tested and re ported, with 92% of isolates. Trimethoprim-sulfamethoxazole, Chloramphenicol, Ceftriaxone, and Azithromycin follow closely, with 87% while Meropenem and Imipenem tested in 87% and 71% respectively, among isolates from all specimen sources.

S. Typhi isolates exhibit high-level resistance to first-line antibiotics previously used for typhoid treatment, including Ampicillin (83.2%), chloramphenicol (78.7%), and Trimethoprim-sulfamethoxazole (67.2%). Additionally, 74.5% of isolates are resistant to ciprofloxacin, and 61.4% are resistant to ceftriaxone.

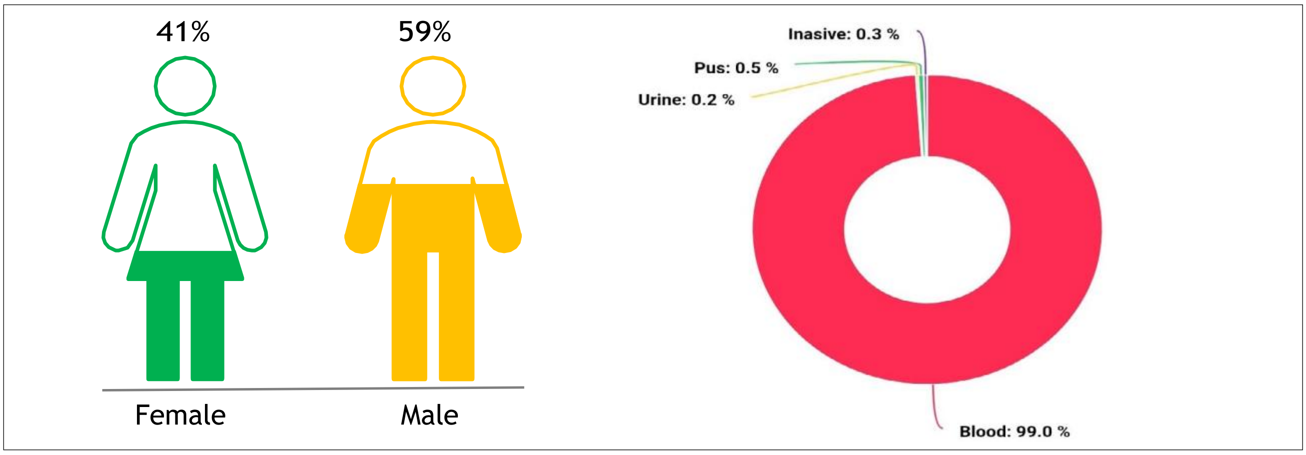


Figure 3.7: *Salmonella* Typhi: proportion of isolates among different specimen types, 2021

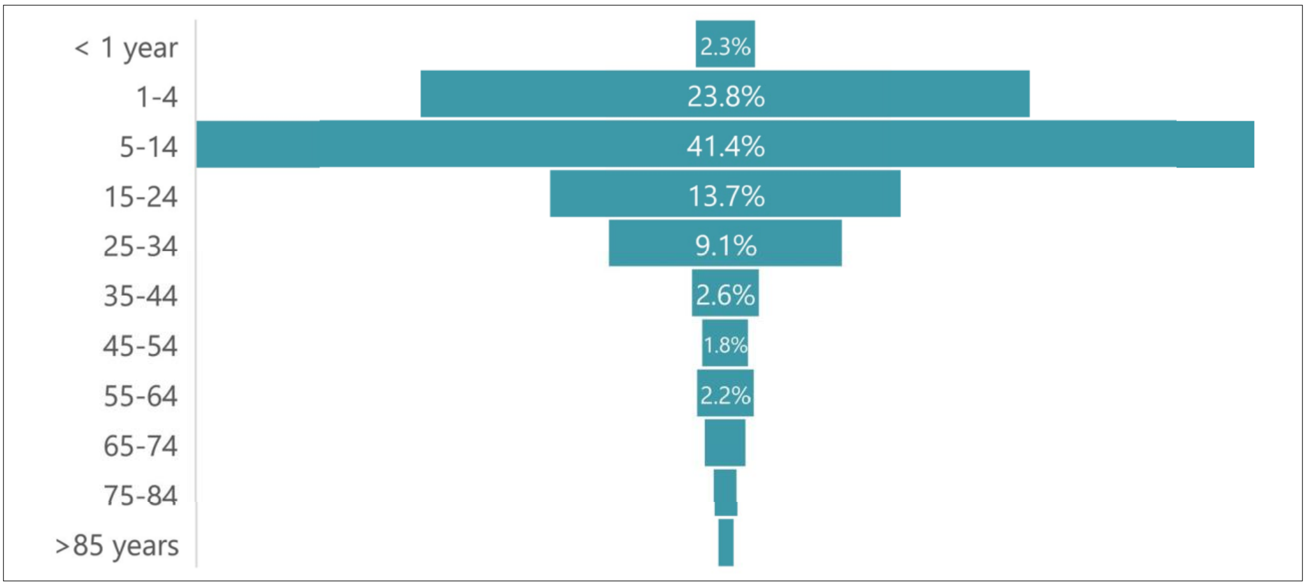


Figure 3.8: *Salmonella* Typhi: gender wise Distribution, 2021

Table 3.3: Percentages of resistant, susceptible and intermediate isolates for *Salmonella* Typhi, isolates from all sources, Pakistan, 2021

Salmonella Typhi (n=2,309)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	2,135	83.0	0.0	17.0
Ceftriaxone	CRO	2,013	71.4	0.1	28.5
Cefotaxime	CTX	495	61.4	0.0	38.6
Cefixime	CFM	1,248	57.0	0.0	43.0
Imipenem	IPM	1,644	0.1	0.0	99.8
Meropenem	MEM	1,961	0.1	0.0	99.8
Ciprofloxacin	CIP	2,145	74.5	18.0	7.6
Levofloxacin	LVX	258	55.8	1.6	42.6
Trimethoprim-Sulfamethoxazole	SXT	2,020	67.2	0.0	32.8
Azithromycin	AZM	2,004	1.8	0.1	98.1
Chloramphenicol	CHL	2,025	78.7	0.0	21.3

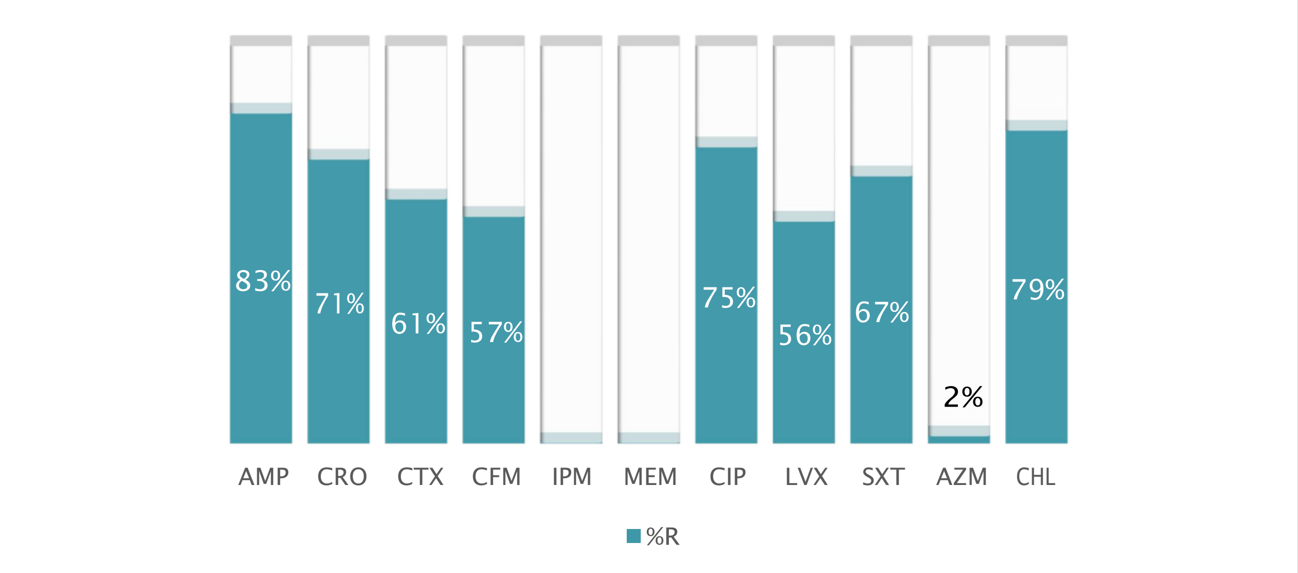


Figure 3.9: Percentages of resistant isolates for *Salmonella* Typhi, isolates from all sources, Pakistan, 2021

3.4 *Pseudomonas aeruginosa*:

For the year 2021, 19 sentinel sites reported 5,011 isolates of *Pseudomonas aeruginosa*. Over 50% of all *Pseudomonas aeruginosa* pathogens are isolated from pus specimens, and around 19% from urine. The age-wise distribution shows a non-significant variation among age categories, as almost equal proportions of *P. aeruginosa* are isolated from all age groups ranging from 5 to 84 years with slightly higher incidence among 15-34 years age group.

Among these, the most tested and reported antimicrobials were Amikacin at 95%, cefepime at 92%, ciprofloxacin, and Tobramycin at 90%, and Imipenem and Meropenem at 89%, respectively, in isolates from all specimen sources. Resistance in *Pseudomonas aeruginosa* ranges from 25.1% for ceftazidime to 32.4% for the Tobramycin and 38.7% for ciprofloxacin.

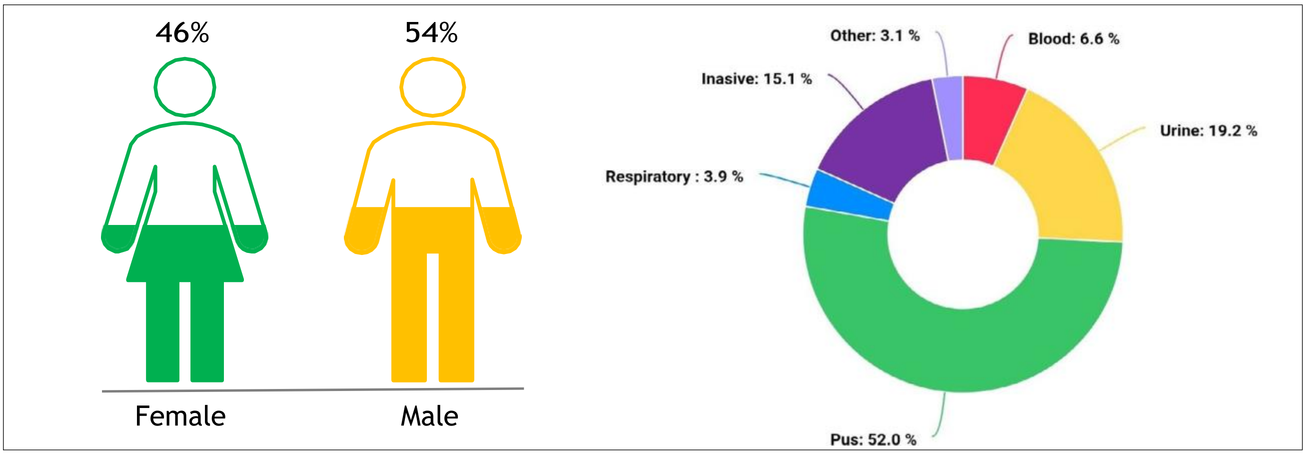


Figure 3.10: *Pseudomonas aeruginosa*: proportion of isolates among different specimen types, 2021

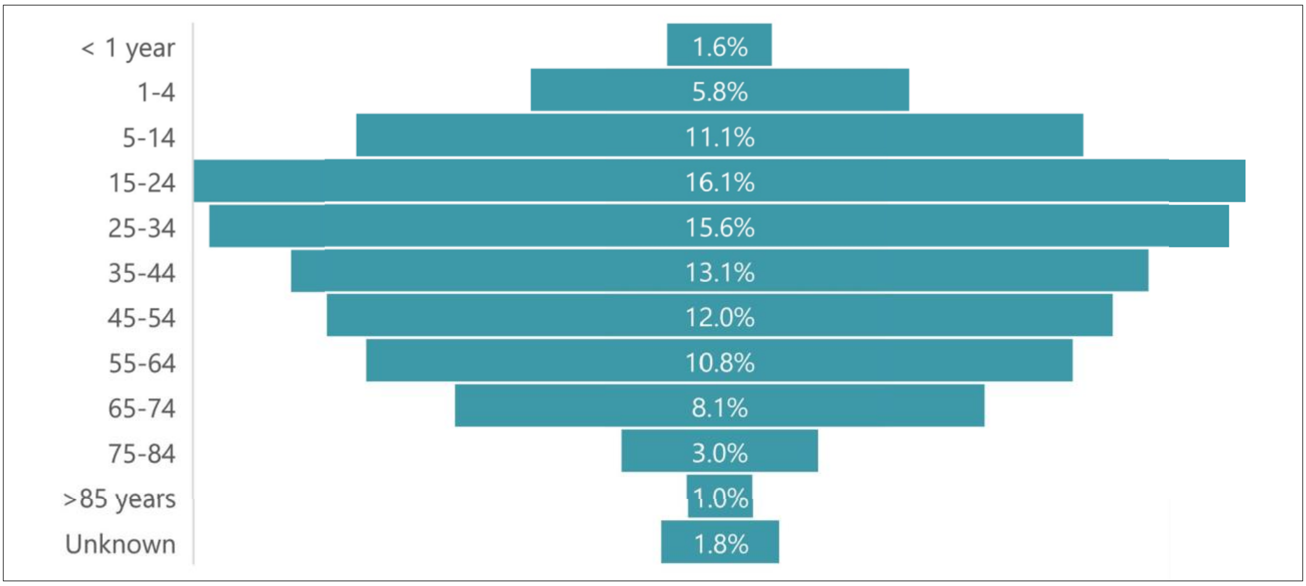


Figure 3.11: *Pseudomonas aeruginosa:* Gender wise distribution, 2021

Table 3.4: Percentages of resistant, intermediate, and susceptible isolates for *Pseudomonas aeruginosa*, isolates from all sources, Pakistan, 2021

Pseudomonas aeruginosa (n=5,011)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Piperacillin/Tazobactam	TZP	3,461	27.4	2.0	70.6
Ceftazidime	CAZ	2,594	25.1	1.0	73.9
Cefepime	FEP	4,620	34.0	1.1	64.9
Imipenem	IPM	4,460	28.2	0.3	71.5
Meropenem	MEM	3,717	30.7	0.2	69.1
Amikacin	AMK	4,765	27.7	1.4	70.8
Gentamicin	GEN	1,236	31.2	0.2	68.6
Tobramycin	TOB	4,532	32.4	0.2	67.4
Ciprofloxacin	CIP	4,533	38.7	1.3	60.0

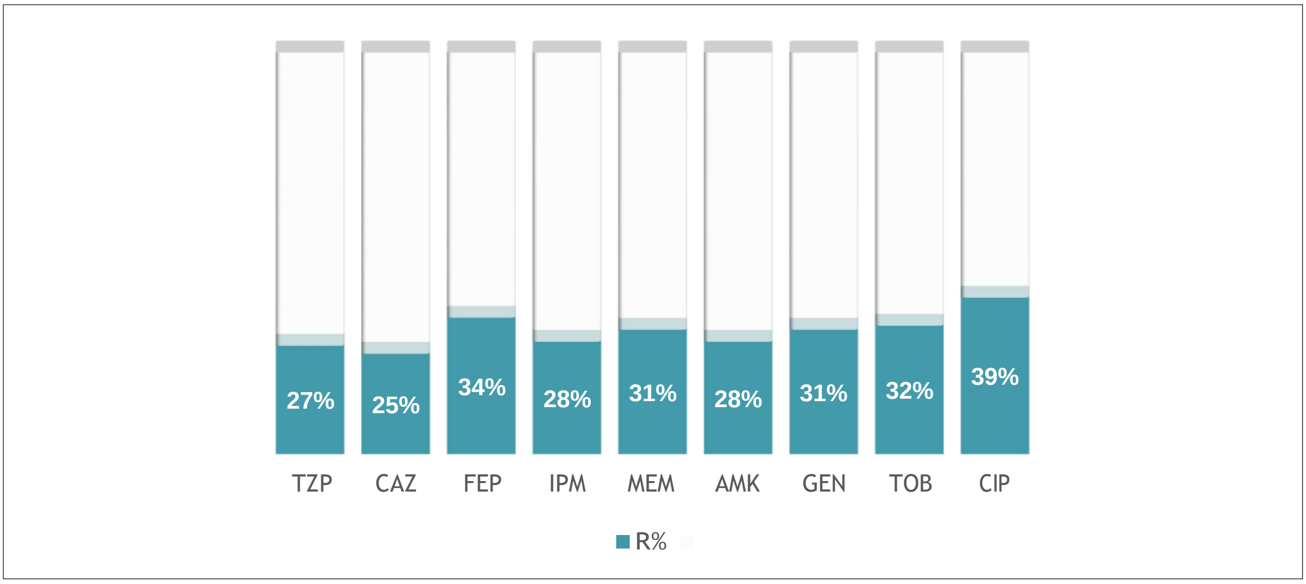


Figure 3.12: Percentages of resistant isolates for *Pseudomonas aeruginosa,* isolates from all sources, Pakistan, 2021

3.5 *Streptococcus pneumoniae:*

For the year 2021, a total of 476 isolates of Streptococcus pneumoniae were reported, primarily from blood and invasive specimens. The prevalence was notably higher among male patients, comprising over 59% (n=277). Age-wise distribution reveals a higher frequency in two specific age groups: children aged 1-4 years (n=60) and older adults aged 55-64 years (n=73).

Among these, the most tested and reported antimicrobials are Penicillin G (95%), ceftriaxone (92%), and Trimethoprim-Sulfamethoxazole (82%), isolated from all specimen sources.

Resistance to *Streptococcus pneumoniae* ranged from 0% for vancomycin and linezolid, 68.6% for Trimethoprim-Sulfamethoxazole, and approximately 34% resistance against Tetracycline.

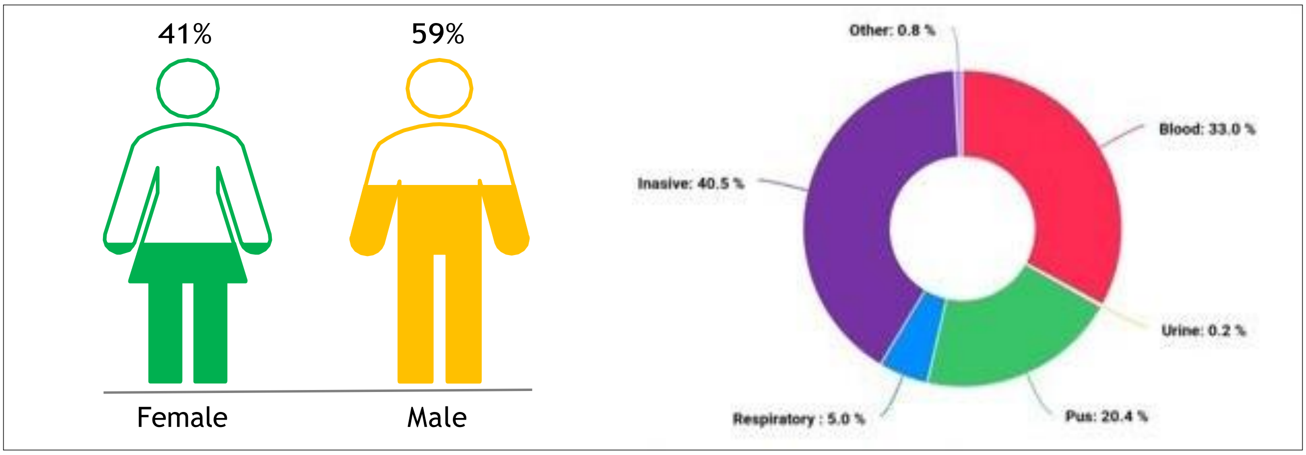


Figure 3.13: *Streptococcus pneumoniae*: proportion of isolates among different specimen types, 2021

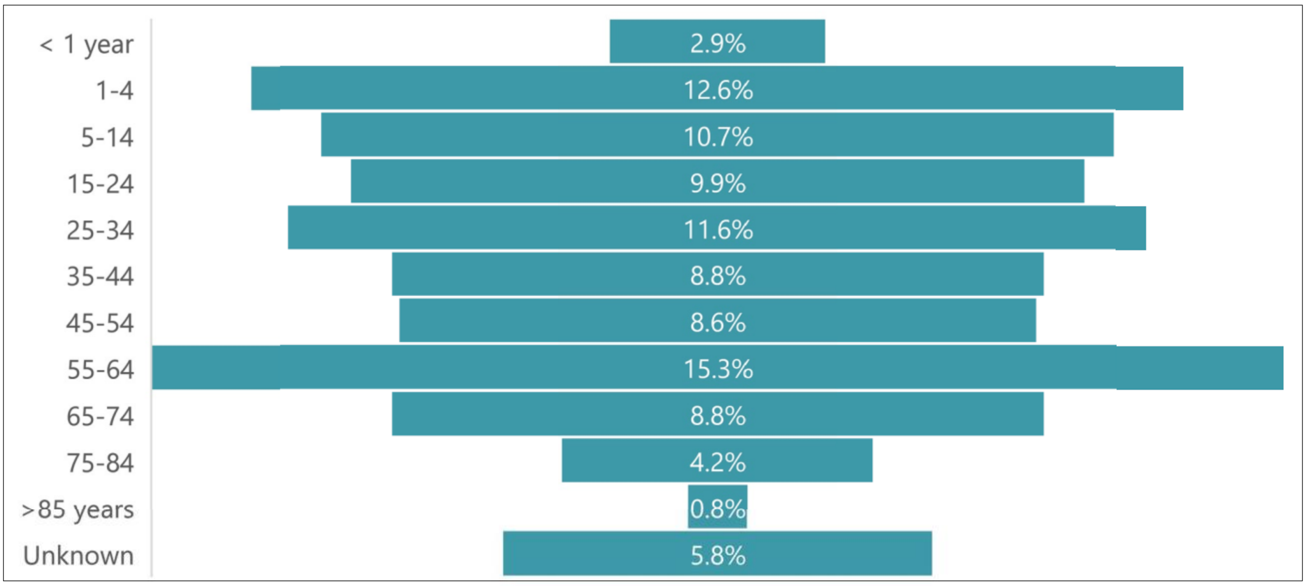


Figure 3.14: *Streptococcus pneumoniae*: Gender wise distribution, 2021

Table 3.5: Percentages of resistant, intermediate, and susceptible isolates for *Streptococcus pneumoniae*, isolates from all sources, Pakistan, 2021

Streptococcus pneumoniae (n=476)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Penicillin G	PEN	453	43.9	0.2	55.8
Ampicillin	AMP	279	3.9	1.4	94.6
Ceftriaxone	CRO	442	0.0	0.0	100
Ciprofloxacin	CIP	75	4.0	0.0	96.0
Levofloxacin	LVX	206	7.3	0.5	92.2
Trimethoprim-Sulfamethoxazole	SXT	388	68.6	1.5	29.9
Clindamycin	CLI	226	23.9	0.9	75.2
Erythromycin	ERY	198	32.8	0.5	66.7
Linezolid	LNZ	99	0.0	0.0	100.0
Vancomycin	VAN	233	0.0	0.0	100.0
Tetracycline	TCY	73	34.2	0.0	65.8

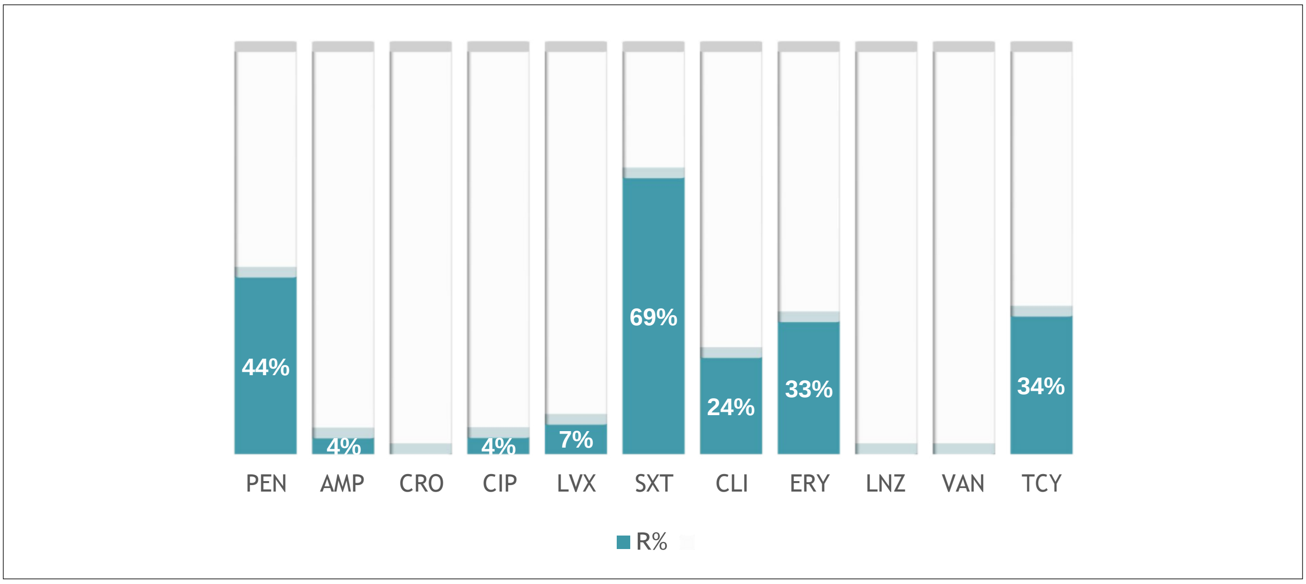


Figure 3.15: Percentages of resistant isolates for *Streptococcus pneumoniae*, isolates from all sources, Pakistan, 2021

3.6 *Staphylococcus aureus:*

In the year 2021, a total of 20,633 isolates of *Staphylococcus aureus* were reported. *Staphylococcus aureus* was predominantly reported from pus specimens, constituting over 60% (n=12,471) of the total isolates. In terms of gender distribution, it was more prevalent in males (n=11,591, 56%). The age group (25-34, 15.5%) shows high prevalence as compare to other age categories.

Among these antimicrobials, Oxacillin has been tested and reported in 79% of cases, followed by clindamycin at 60%, and both Erythromycin and Linezolid at 58% for isolates from all specimen sources. *Staphylococcus aureus* exhibits a range of resistance levels, from 0% for vancomycin to 78% for ciprofloxacin. Additionally, resistance rates against oxacillin are reported at 67.7%, and against cefoxitin at 65.8%.

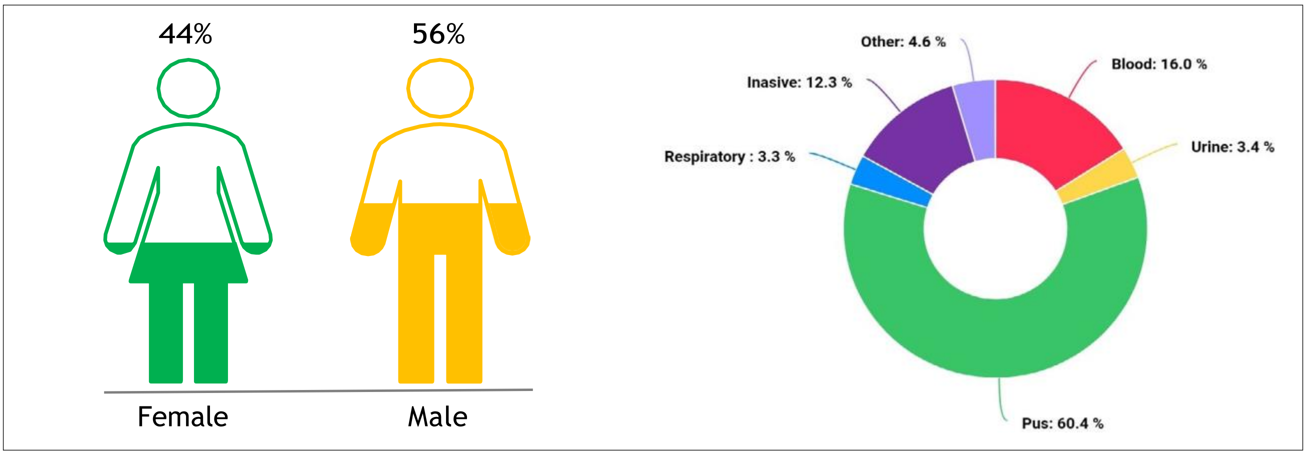


Figure 3.16: *Staphylococcus aureus:* proportion of isolates among different specimen types

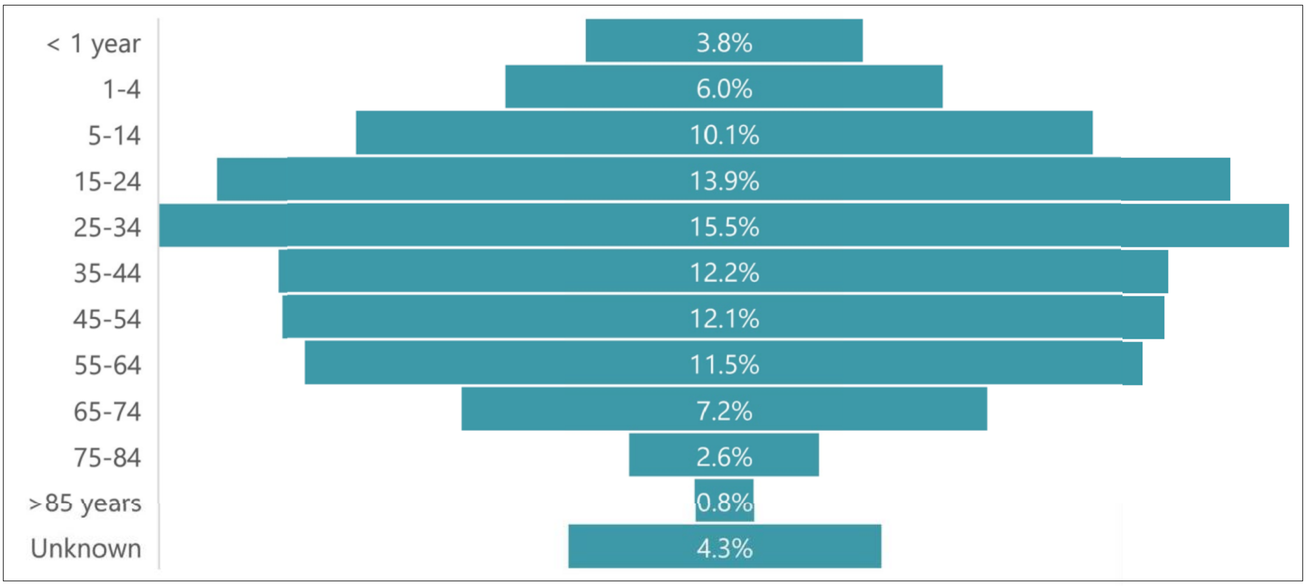


Figure 3.17: *Staphylococcus aureus:* Age wise distribution

Table 3.6: Percentages of resistant, intermediate, and susceptible isolates for *staphylococcus aureus* isolates from all sources, Pakistan, 2021

Staphylococcus aureus (n=20,633)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Oxacillin	OXA	16,371	67.6	0.0	32.4
Cefoxitin	FOX	1,482	65.8	0.0	34.2
Amikacin	AMK	7,531	8.3	0.3	91.5
Gentamicin	GEN	10,149	26.4	0.3	73.4
Rifampin	RIF	1,787	8.8	0.0	91.2
Ciprofloxacin	CIP	9,601	78.1	0.6	21.3
Levofloxacin	LVX	4,989	72.4	1.1	26.5
Moxifloxacin	MFX	1,426	60.4	1.6	38.0
Trimethoprim-Sulfamethoxazole	SXT	11,648	32.4	0.1	67.6
Clindamycin	CLI	12,395	21.1	1.8	77.1
Erythromycin	ERY	11,997	61.5	0.4	38.1
Linezolid	LNZ	12,074	0.1	0.0	99.9
Vancomycin	VAN	10,492	0.0	0.0	100.0
Tigecycline	TGC	1,265	3.5	0.2	96.4

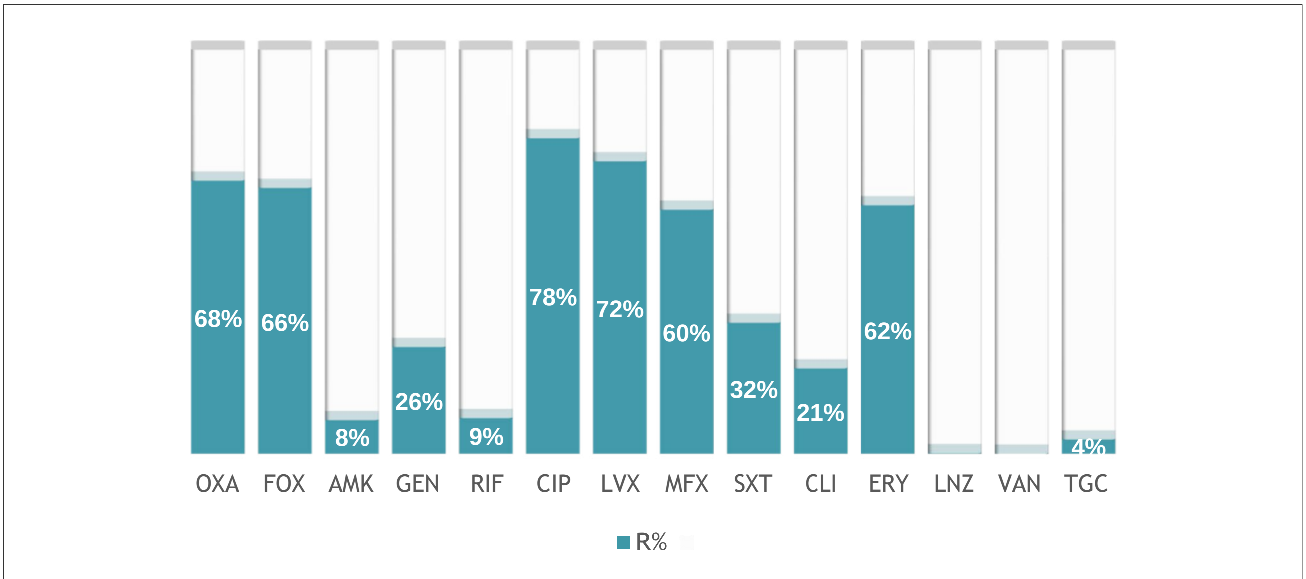


Figure 3.18: Percentages of resistant isolates for *staphylococcus aureus* isolates from all sources, Pakistan, 2021

3.7 Neisseria gonorrhoeae:

In 2021, a total of 68 isolates of *Neisseria gonorrhoeae* were reported. Typically, over 95% of these isolates are obtained from urethral swabs, with a higher prevalence observed in the adult age groups of >15 to <44 years (n=61).

Among these, the most tested and reported antimicrobials are ceftriaxone, tested in all isolates, ciprofloxacin in 98% of isolates, and cefixime in 96% of isolates from all specimen sources. For the year 2021, *Neisseria gonorrhoeae* isolates showed an 88% resistance to ciprofloxacin, while isolates remained sensitive to ceftriaxone and cefixime.

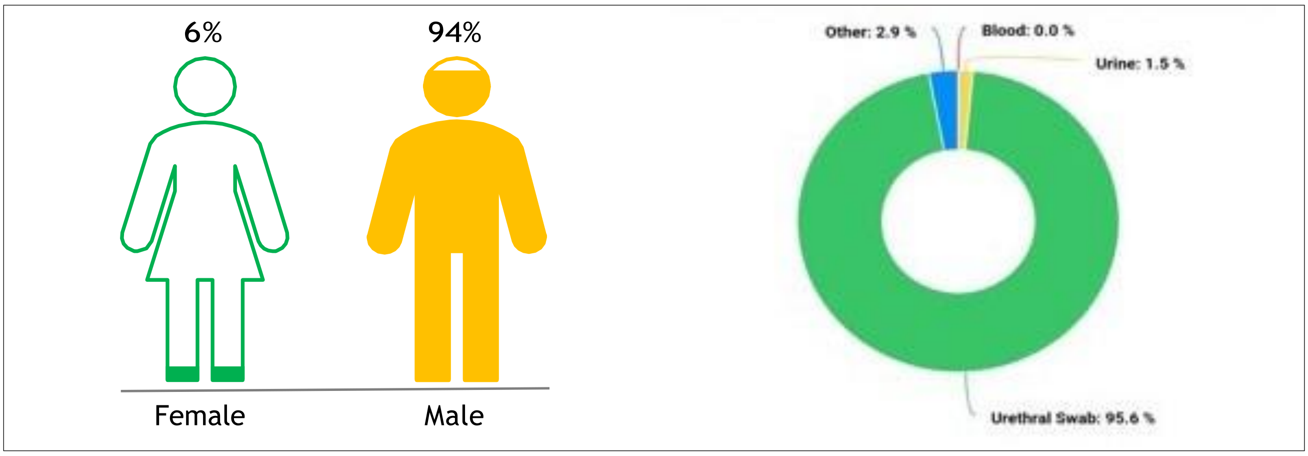


Figure 3.19: *Neisseria gonorrhoeae:* proportion of isolates among different specimen types

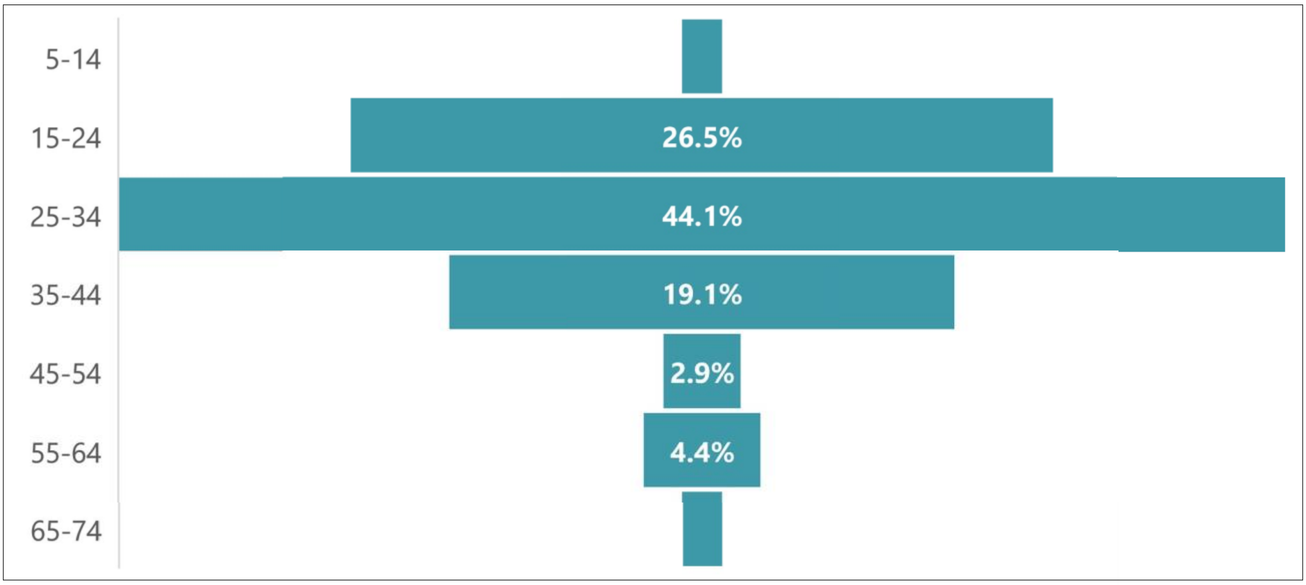


Figure 3.20: *Neisseria gonorrhoeae*: Age wise distribution

Table 3.7: Percentages of resistant, intermediate, and susceptible isolates for *Neisseria gonorrhoeae* isolates from all sources, Pakistan, 2021

Neisseria gonorrhoeae (n=68)					
Antibiotic	Code	Isolates(n)	R%	I%	S%
Ceftriaxone	CRO	68	0	0	100
Cefixime	CFM	65	0	0	100
Spectinomycin	SPT	38	0	0	100
Ciprofloxacin	CIP	67	88	9	3
Azithromycin	AZM	58	5	0	95

Figure 3.21: Percentages of resistant isolates for *Neisseria gonorrhoeae* isolates from all sources, Pakistan, 2021

3.8 *Shigella spp:*

In the year 2021, a total of 84 isolates of *Shigella spp* were reported. Out of the total 84 isolates reported, the majority were isolated from stool samples, with around 10% originating from blood samples. In terms of age distribution, the under-5 age group exhibited a higher number (n=35) compared to the older age groups.

Among these, the most tested and reported antimicrobials are ceftriaxone, ciprofloxacin in 98% of cases, and Azithromycin in 58% of isolates across all specimen sources.

In 2021, *Shigella spp* isolates demonstrated resistance rates of 92% to Ampicillin and 83.3% to Trimethoprim-Sulfamethoxazole. Additionally, 32.5% of isolates were resistant to ciprofloxacin. However, carbapenems remained effective against all reported isolates.

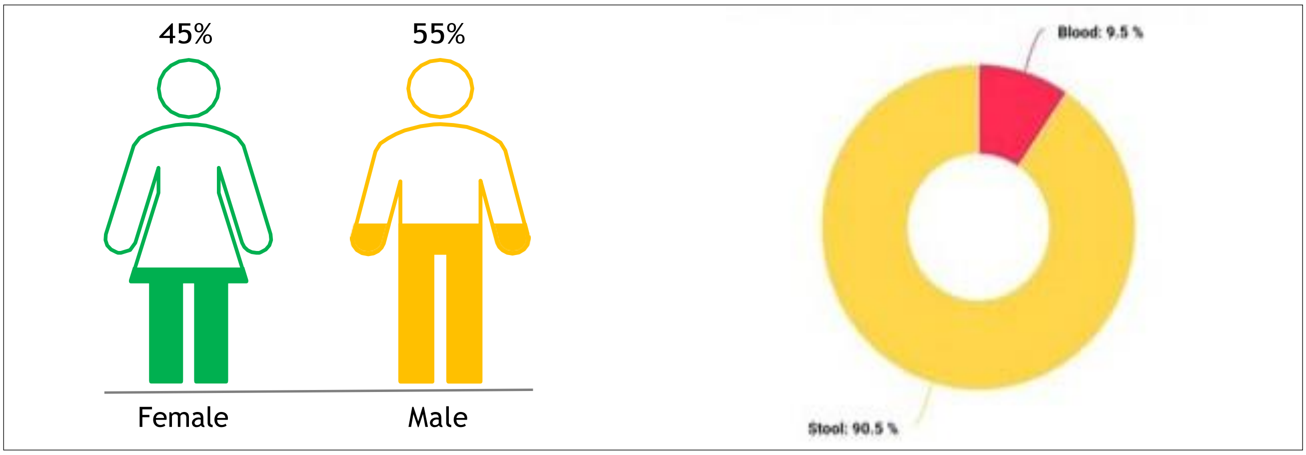


Figure 3.22: *Shigella spp:* proportion of isolates among different specimen types-2021

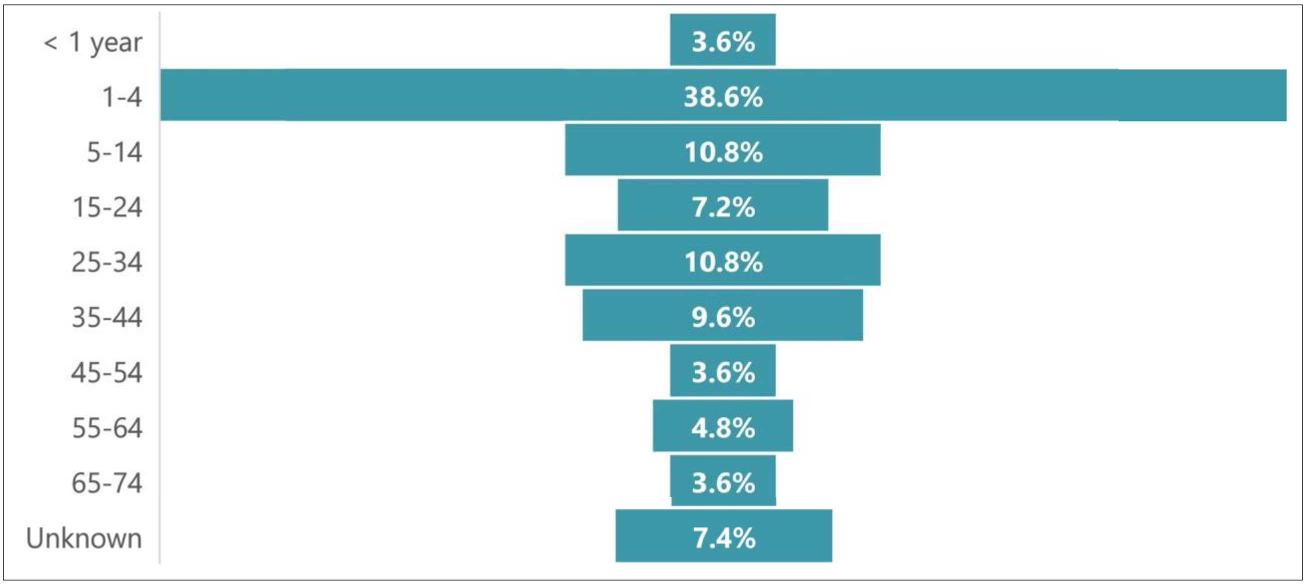


Figure 3.23: *Shigella spp:* Age wise distribution-2021

Table 3.8: Percentages of resistant, intermediate, and susceptible isolates for *shigella spp*. isolates from all sources, Pakistan, 2021

Shigella spp (n=84)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	25	92	0	8
Ceftriaxone	CRO	84	52.4	0	47.6
Imipenem	IPM	20	0	0	100
Meropenem	MEM	23	0	0	100
Ciprofloxacin	CIP	83	32.5	15.7	51.8
Trimethoprim/Sulfamethoxazole	SXT	24	83.3	0	16.7
Azithromycin	AZM	49	2	0	98.0
Chloramphenicol	CHL	25	32	0	68

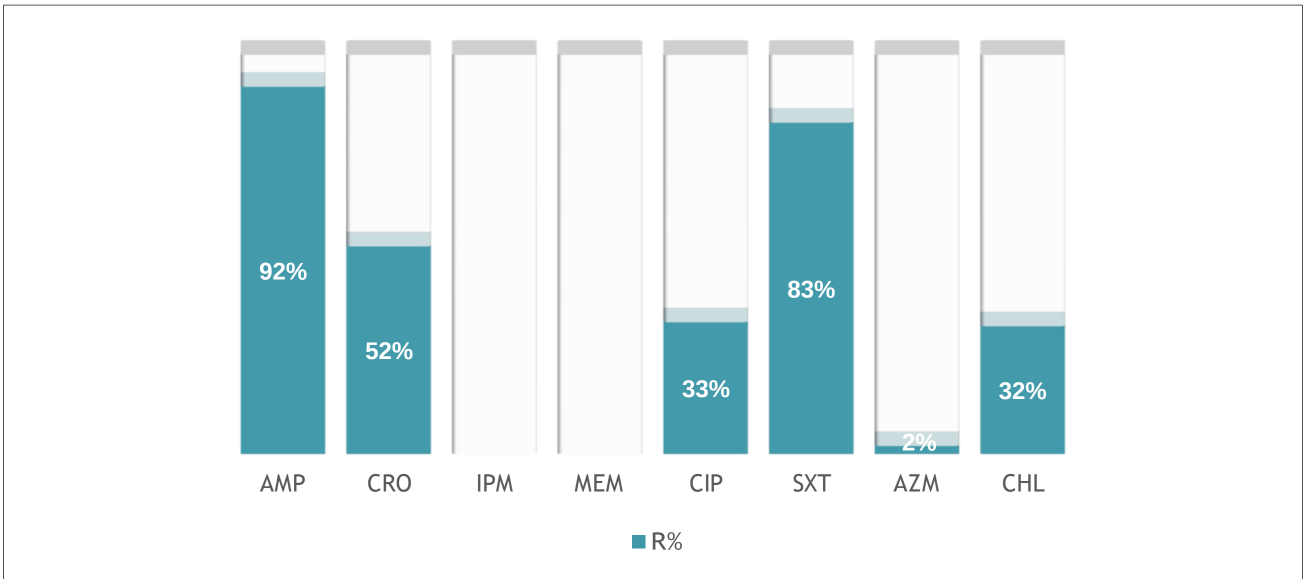
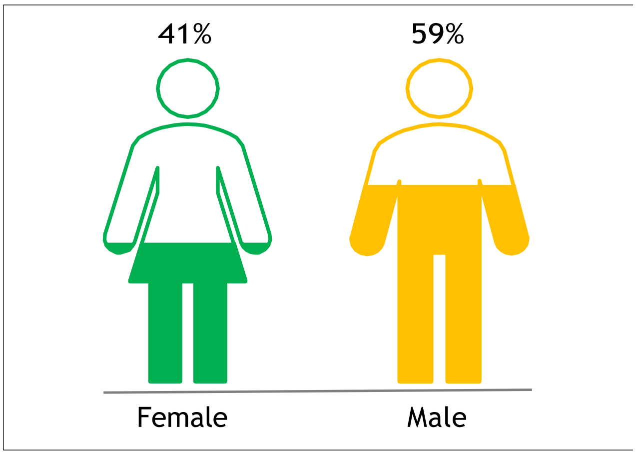


Figure 3.24: Percentages of resistant isolates for *shigella spp*. isolates from all sources, Pakistan, 2021

3.9 Acinetobacter species:

In 2021, a total of 4,941 isolates of *Acinetobacter species* were reported. More than 35% (n=1,747) of these isolates were found in blood specimens, followed by 20% (n=993) in respiratory specimens. The prevalence was higher among male patients (n=2,910) compared to females. Age-wise distribution did not show any significant variation among age categories. Among these isolates, the most frequently tested and reported antimicrobials were Amikacin (96%), Imipenem and Meropenem (88% each), and Colistin (52% of isolates from all specimen sources).

Acinetobacter spp isolates exhibited a high level of resistance to the reported antibiotics, ranging from 99% resistance against Ampicillin, 94% resistance to Amoxicillin-clavulanic acid and Ceftriaxone, 74% resistance in Carbapenems (Imipenem and Meropenem), and 3% resistance against Colistin.



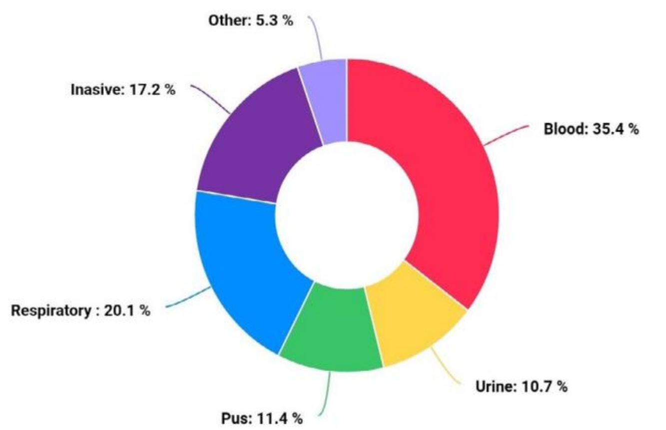


Figure 3.25: *Acinetobacter species*: proportion of isolates among different specimen types, 2021

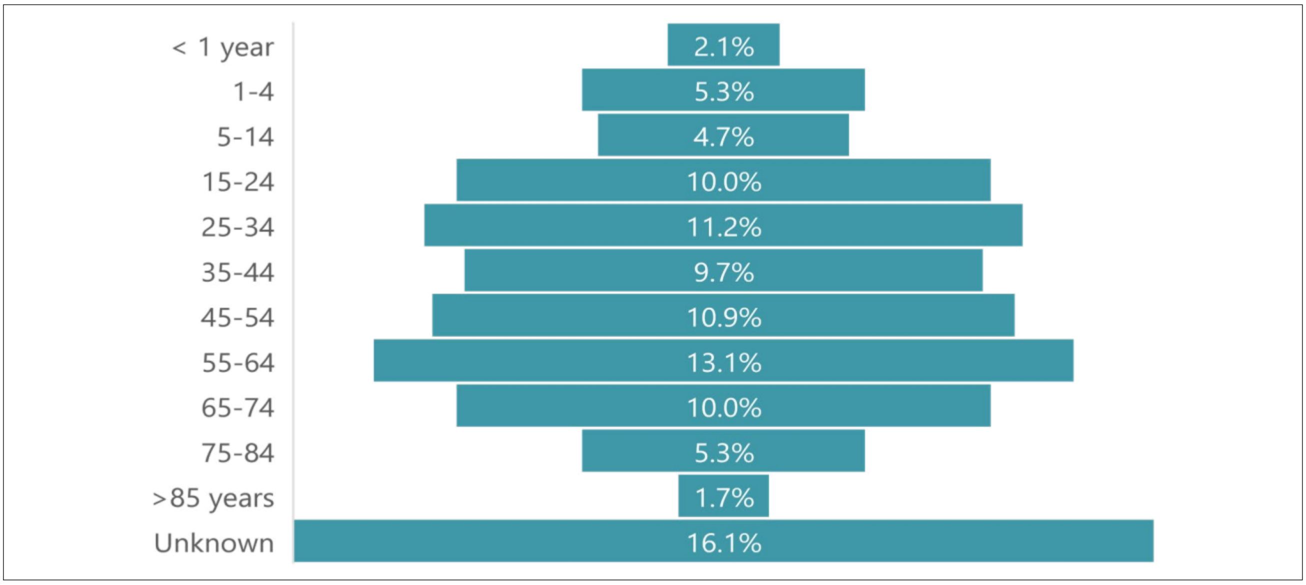


Figure 3.26: *Acinetobacter species*: Gender wise distribution, 2021

Table 3.9: Percentages of resistant, intermediate, and susceptible isolates for *Acinetobacter spp.*, isolates from all sources, Pakistan, 2021

Acinetobacter Spp (n=4,941)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	677	99	0	1
Amoxicillin/Clavulanic acid	AMC	684	94	1	5
Piperacillin /tazobactam	TZP	1,688	75	1	24
Ceftazidime	CAZ	971	81	2	18
Ceftriaxone	CRO	978	94	1	4
Cefepime	FEP	998	82	1	17
Imipenem	IPM	4,366	74	1	25
Meropenem	MEM	4,260	74	1	25
Amikacin	AMK	4,770	64	2	34
Gentamicin	GEN	3,681	57	4	39
Ciprofloxacin	CIP	1,962	82	1	17
Trimethoprim/Sulfamethoxazole	SXT	1,587	70	0	30
Doxycycline	DOX	273	41	0	59
Minocycline	MNO	1,259	12	6	82
Tigecycline	TGC	2,095	53	25	22

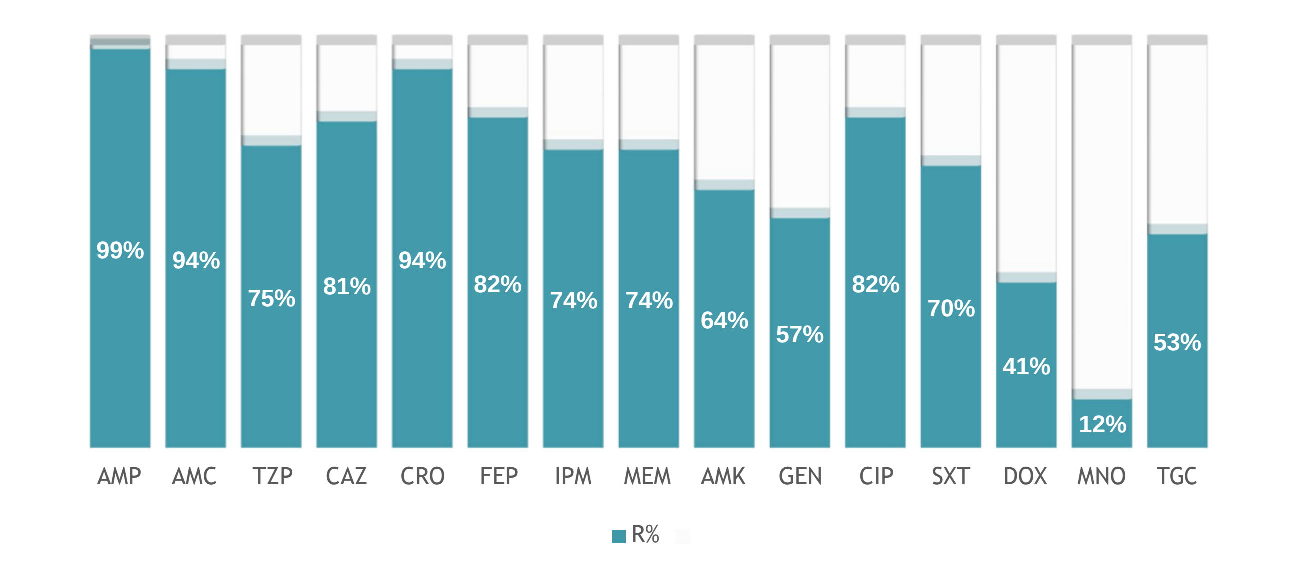


Figure 3.27: Percentages of resistant isolates for *Acinetobacter spp.*, isolates from all sources, Pakistan, 2021

3.10 MDR, XDR & PDR summary, Pakistan-2021:

Table 3.10: MDR, XDR & PDR summary, 2021

Organism	Number of isolates	MDR	Possible XDR	Possible PDR
E. coli	58,457	30,564 (52.3%)	8,625 (14.8%)	2,081 (3.6%)
Staphylococcus aureus	20,633	9,403 (45.6%)	818 (3.9%)	0 (0%)
Klebsiella pneumoniae	15,446	8,003 (51.8%)	3,916 (25.4%)	1,341 (8.7%)
Pseudomonas aeruginosa	5,011	1,606 (32.0%)	1,432 (28.6)	73 (1.5%)
Acinetobacter spp.	4,941	3,458 (69.9%)	3,359 (67.9%)	1,022 (20.6%)
Salmonella Typhi	2,309	1,190 (52%)	880 (38%)	0 (0%)
Streptococcus pneumoniae	476	0 (0%)	0 (0%)	0 (0%)
Total	107,273	53,034(49.4%)	18,150(16.9%)	4,777(4.5%)

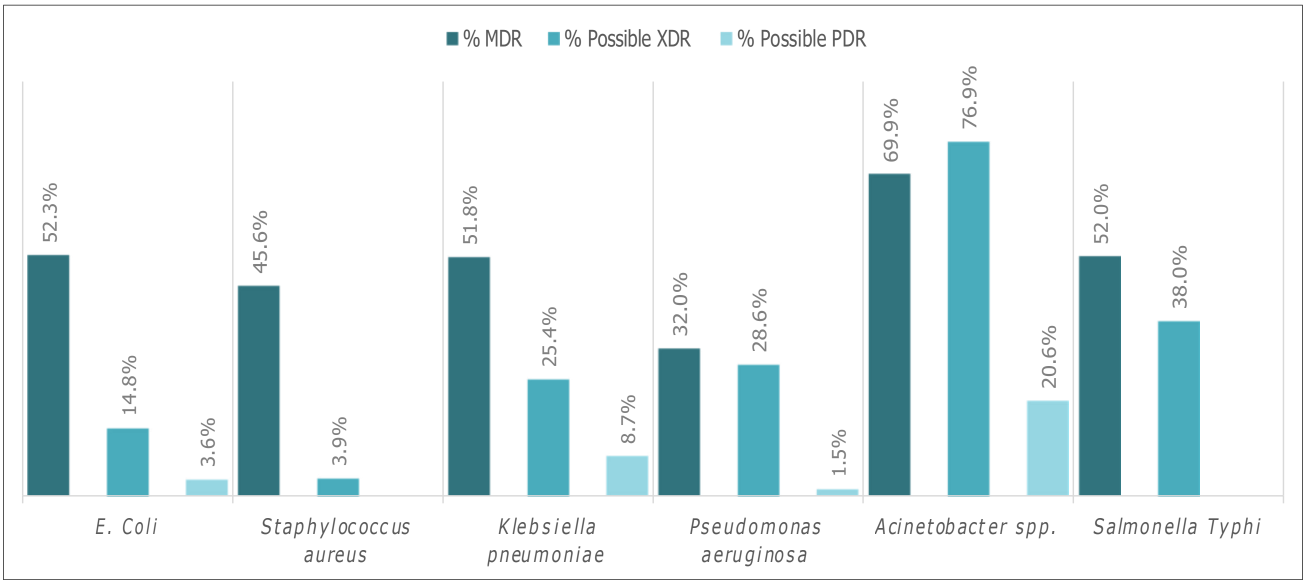


Figure 3.28: MDR, XDR & PDR summary, 2021

4. Demographic and Sensitivity pattern of Priority Pathogens during 2022

For the reporting period January-December 2022, a total of 229,617 non-duplicate isolates from 26 surveillance sites/laboratories were available for analysis. The most frequently reported pathogens were *E. coli* (36%), followed by *K. pneumoniae* (12%), *S. aureus* (10%), *P. aeruginosa* (8%) and *S. Typhi* (7%).

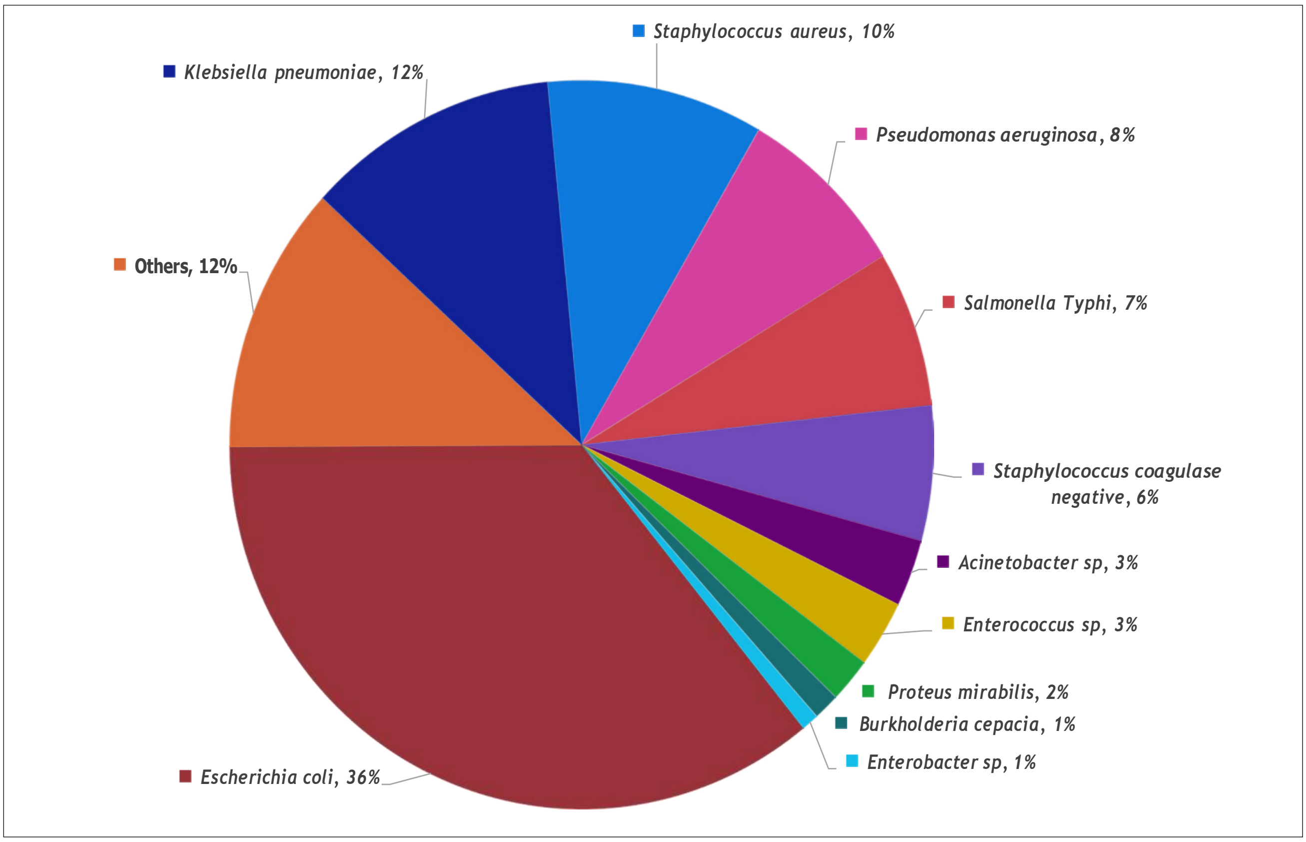


Figure 4.0: Distribution of AMR priority pathogens 2022 (n= 229,617)

4.1 Escherichia coli:

In the year 2022, a total of 26 sentinel sites reported 82,679 isolates of *E. coli.* According to the data, 82% (n=67,740) of these isolates were found in urine specimens, with 66% (n=54,885) specifically in female patients. This higher prevalence among females can be attributed to the increased incidence of urinary tract infections in this demographic. Additionally, the data indicates a higher prevalence of *E. coli* infections in the older age group (especially age group of 55-74 years) compared to the younger population.

Among these, the most tested and reported antimicrobials are Ceftriaxone, in 77,998 (94%) of isolates, Ciprofloxacin with 68,406 (83%), Trimethoprim-Sulfamethoxazole with 61,963 (75%) instances, and Amikacin , 69.3%. For *E. coli* isolates from all specimen sources, resistance to antimicrobials varied, ranging from 92% for Ampicillin to 7% for Fosfomycin, based on data reported in 2022. Similarly, among cephalosporins, 78% and 77% of the isolates are resistant to cefuroxime and cefotaxime respectively. Furthermore, resistance rates to ciprofloxacin and Trimethoprim-Sulfamethoxazole stand at 69.5% and 68.5% respectively.

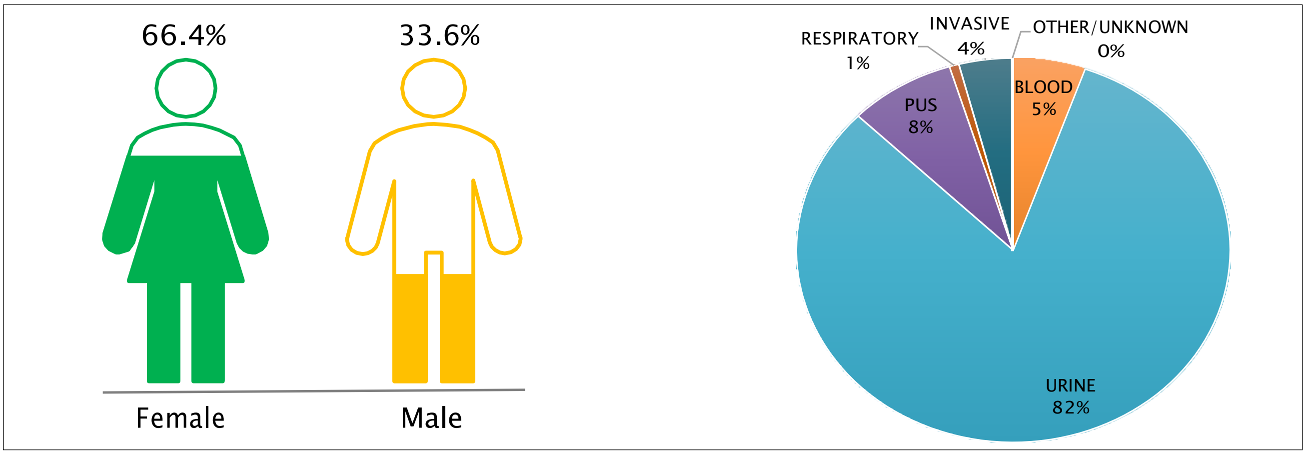


Figure 4.1: *E. coli:* proportion of isolates among different specimen types & gender wise, 2022

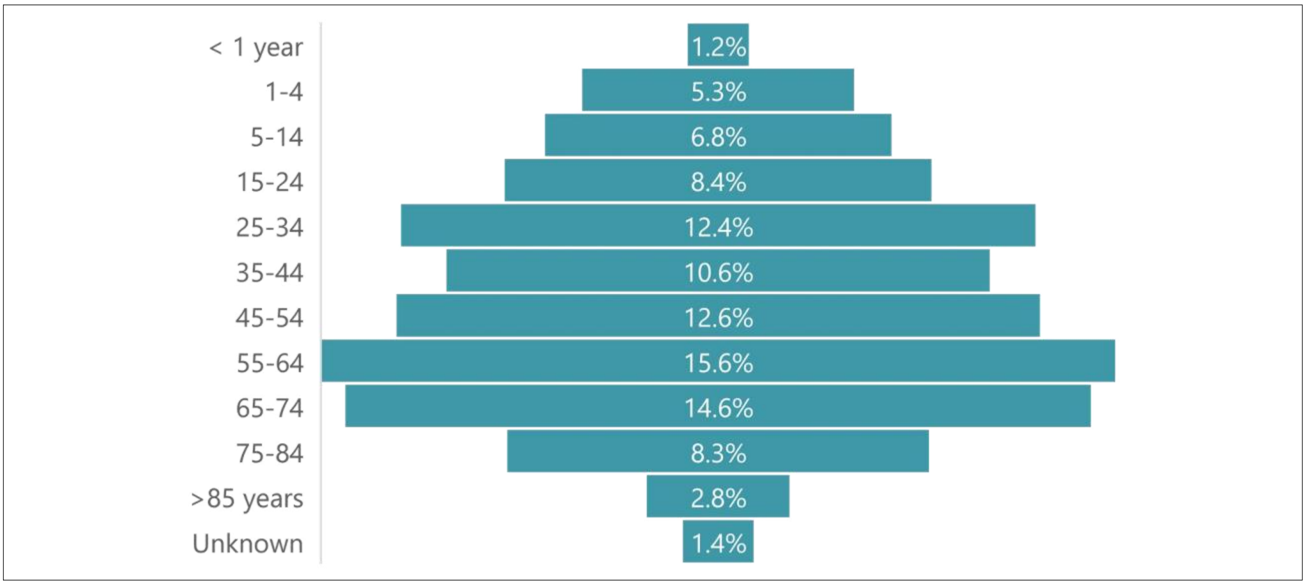


Figure 4.2: *E. coli:* Gender wise distribution, 2022

Table 4.1: Percentages of resistant, susceptible and intermediate isolates for *E. coli*, (isolates from all sources), Pakistan, 2022

E. coli (n=82,679)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	54,058	91.7	0.3	8.1
Amoxicillin-Clavulanic acid	AMC	47,310	62.0	0.8	37.2
Piperacillin-Tazobactam	TZP	60,483	20.2	1.9	77.9
Cefuroxime	CXM	42,914	78.0	0.3	21.7
Ceftazidime	CAZ	11,719	73.5	2.2	24.2
Ceftriaxone	CRO	77,998	74.6	0.1	25.3
Cefotaxime	CTX	19,654	76.5	0.2	23.3
Cefepime	FEP	10,315	73.3	3.2	23.5
Ertapenem	ETP	30,697	11.0	0.7	88.3
Imipenem	IPM	42,035	14.4	0.9	84.7
Meropenem	MEM	53,022	13.5	0.4	86.2
Amikacin	AMK	57,325	8.8	1.3	90.0
Gentamicin	GEN	46,429	27.9	0.6	71.4
Tobramycin	TOB	14,879	27.4	0.7	71.9
Ciprofloxacin	CIP	68,406	69.5	2.1	28.4
Trimethoprim-Sulfamethoxazole	SXT	61,963	68.5	0.1	31.4
Fosfomycin	FOS	46,737	7.1	0.1	92.8
Nitrofurantoin	NIT	49,651	9.2	0.8	90.0
Tigecycline	TGC	3,836	7.5	2.4	90.1

[a] Fosfomycin and Nitrofurantoin: Isolates from the urinary tract only.

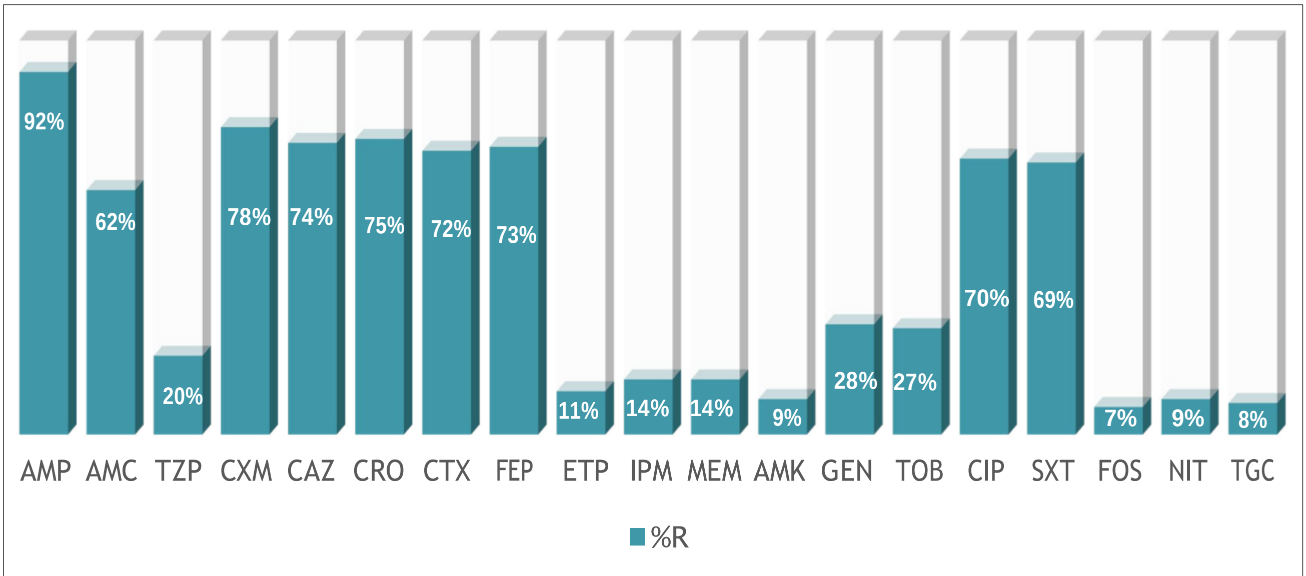


Figure 4.3: Percentages of resistant isolates for *E. coli*, (isolates from all sources), Pakistan, 2022

4.2 Klebsiella pneumoniae:

In the year 2022, a total of 26 sentinel sites reported 27,617 isolates of *Klebsiella pneumoniae*. The reported data shows that 53% (n=14,656) were found in urine specimens, followed by 17% (n=4,649) in blood specimens. It appears to be more prevalent in female patients, accounting for 55% (n=15,045) of cases compared to males. Furthermore, in terms of age distribution, it is more prevalent in the older age group (>25 years) compared to the younger population.

Among these antimicrobials, ceftriaxone has been the most extensively tested and reported, 94.5% of cases, followed by ciprofloxacin at 76.5%, Piperacillin Tazobactam in 74%, Trimethoprim-sulfamethoxazole in 73.5%, Amikacin at 72%, and Meropenem at 70% in *K. pneumoniae* isolates across all specimen sources.

Resistance against *K. pneumoniae* varied, with cefotaxime exhibiting the highest resistance at 73% and Ertapenem the lowest at 20%. Fluoroquinolones, such as Ciprofloxacin, showed a resistance rate of 54%, while 66% resistance was reported against ceftriaxone, which was the most frequently tested antibiotic. Similarly, carbapenems (Imipenem, Meropenem, and Ertapenem) demonstrated resistance ranging from 21% to 32%.

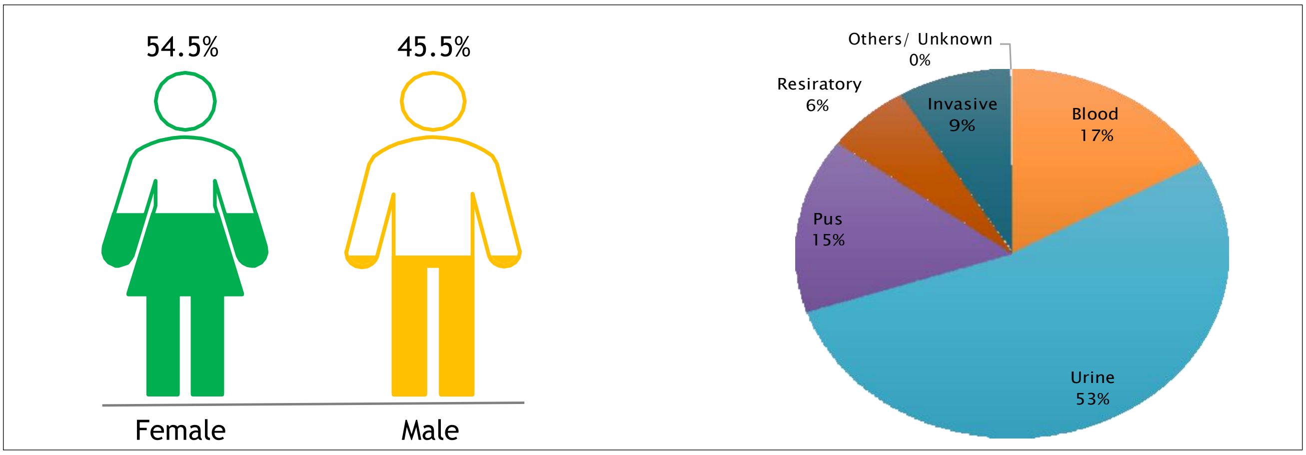


Figure 4.4: *Klebsiella pneumoniae*: proportion of isolates among different specimen types, 2022

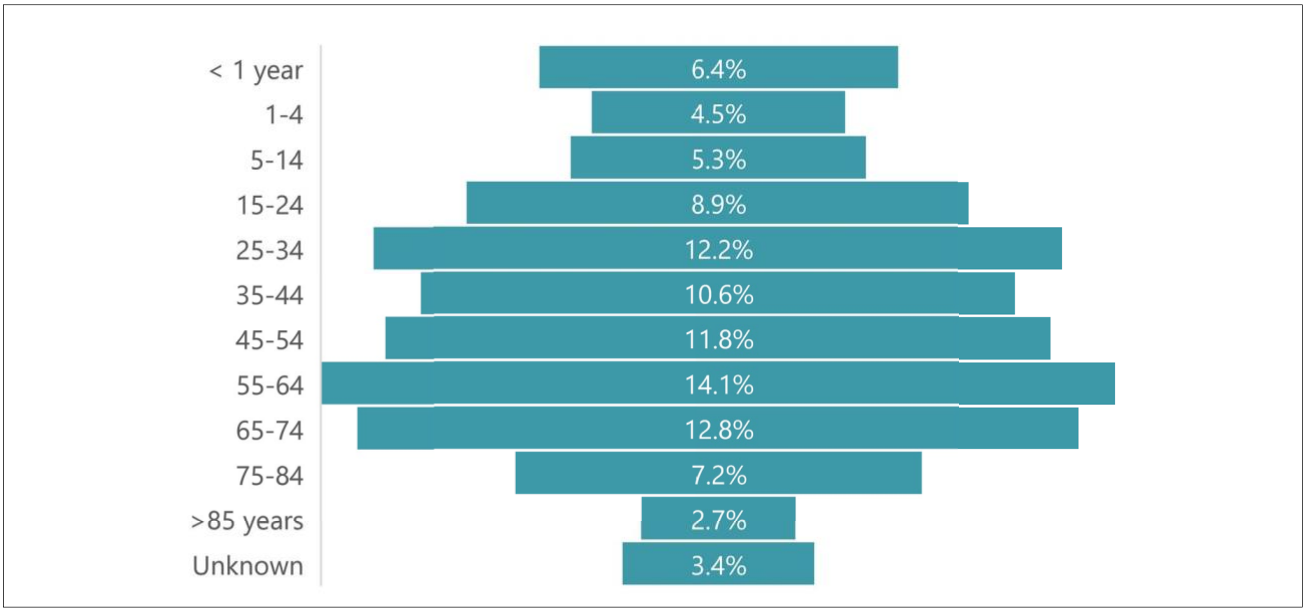


Figure 4.5: *Klebsiella pneumoniae*: Gender wise distribution, 2022

Table 4.2: Percentages of resistant, susceptible and intermediate isolates for *Klebsiella pneumoniae*, (isolates from all sources), Pakistan, 2022

Klebsiella pneumoniae (n=27,617)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Amoxicillin/Clavulanic acid	AMC	15,180	63.3	0.4	36.2
Piperacillin/Tazobactam	TZP	20,459	34.1	2.2	63.7
Cefuroxime	CXM	13,943	71.8	0.0	28.2
Ceftazidime	CAZ	2,106	61.1	0.9	38.1
Ceftriaxone	CRO	26,087	66.4	0.2	33.4
Cefotaxime	CTX	7,656	73.2	0.0	26.8
Cefepime	FEP	3,156	70.0	2.9	27.1
Ertapenem	ETP	7,270	20.6	0.2	79.1
Imipenem	IPM	15,668	32.2	1.2	66.6
Meropenem	MEM	19,502	30.7	0.4	68.9
Amikacin	AMK	19,997	24.0	2.0	74.0
Gentamicin	GEN	14,765	34.2	1.4	64.4
Tobramycin	TOB	6,466	39.6	1.8	58.6
Ciprofloxacin	CIP	21,126	54.0	3.8	42.3
Trimethoprim/Sulfamethoxazole	SXT	20,313	57.0	0.1	42.9
Nitrofurantoin	NIT	9,344	26.0	1.7	72.3

[a] Nitrofurantoin: Isolates from the urinary tract only.

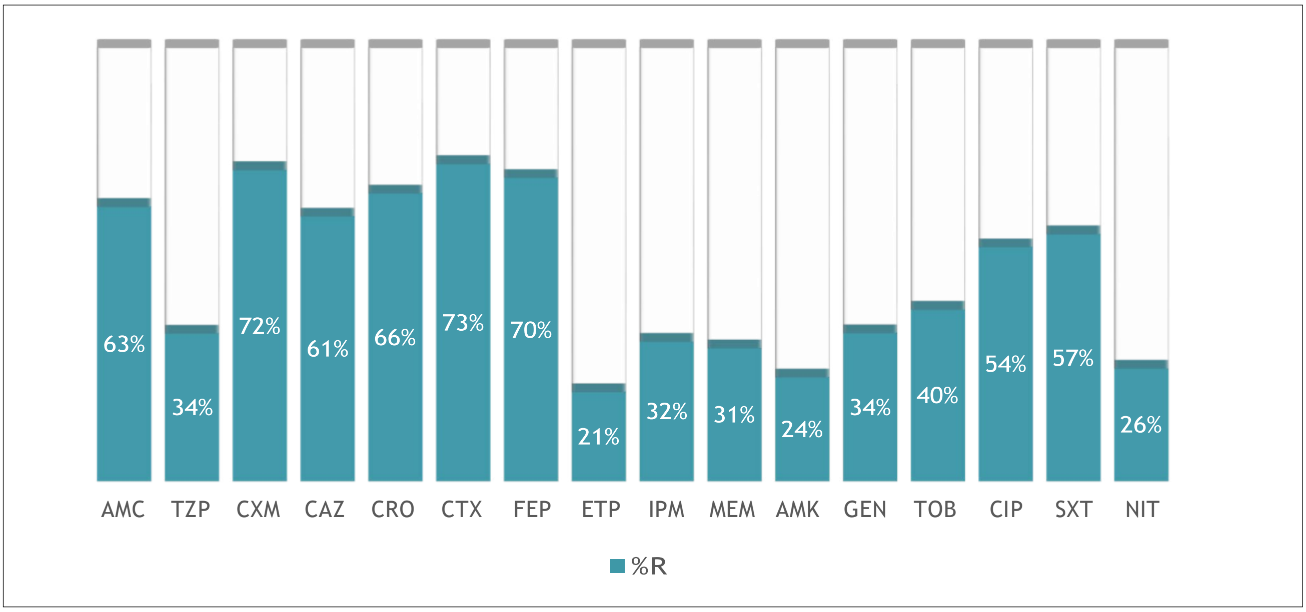


Figure 4.6: Percentages of resistant isolates for *Klebsiella pneumoniae,* isolates from all sources, Pakistan, 2022

4.3 *Pseudomonas aeruginosa*:

In 2022, a total of 26 sentinel sites reported 17,263 isolates of *Pseudomonas aeruginosa*. Of these isolates, over 35% (6,100) were obtained from pus specimens, while around 22% (3,848) were from urine. The age distribution shows a non-significant variation among age categories, with almost equal proportions of *P. aeruginosa* isolated across all age groups (15-74 years), with slightly higher proportion in age group (25-34 years) 13.5% and (55-64 years) 14%.

Among these, the most tested and reported antimicrobials are piperacillin-tazobactam (90%), ceftazidime (85%), amikacin (84%), ciprofloxacin (78%), and gentamicin (74%) of isolates from all specimen sources. Resistance in *Pseudomonas aeruginosa* ranges from 21% for piperacillin-tazobactam to 37% for ciprofloxacin and 34% for cefepime.

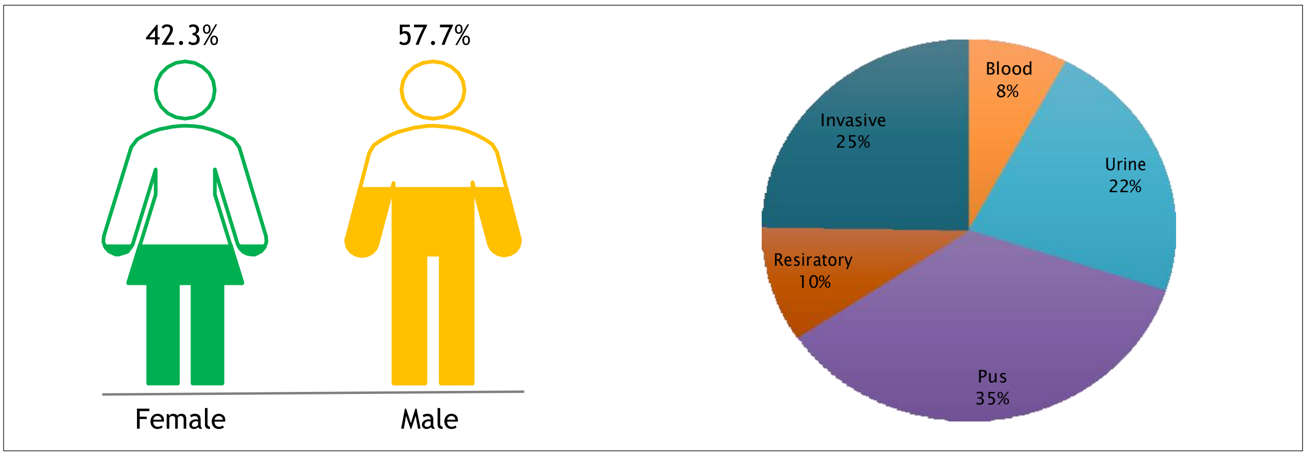


Figure 4.7: *Pseudomonas aeruginosa*: proportion of isolates among different specimen types, 2022

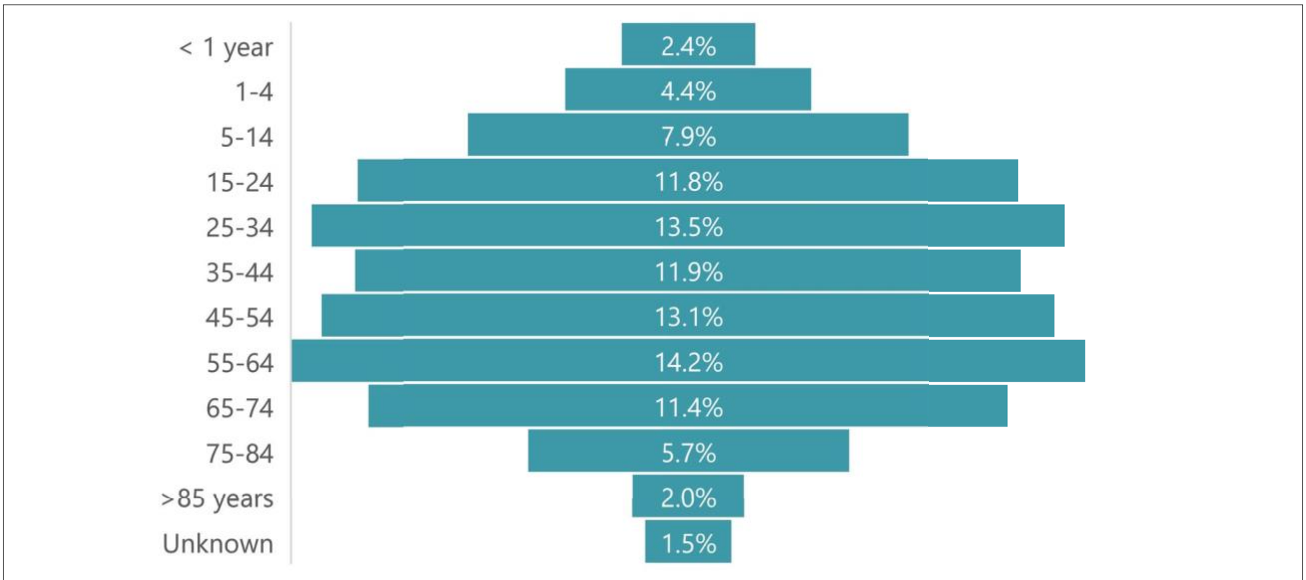


Figure 4.8: *Pseudomonas aeruginosa*: Gender wise distribution, 2022

Table 4.3: Percentages of resistant, intermediate, and susceptible isolates for *Pseudomonas aeruginosa*, isolates from all sources, Pakistan, 2022

Pseudomonas aeruginosa (n=17,263)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Piperacillin/Tazobactam	TZP	15,339	21.0	2.2	76.9
Ceftazidime	CAZ	14,724	26.9	0.4	72.7
Cefepime	FEP	10,591	34.1	1.1	64.8
Imipenem	IPM	11,799	28.4	0.9	70.7
Meropenem	MEM	10,899	27.4	0.7	71.9
Amikacin	AMK	14,493	25.8	0.6	73.5
Gentamicin	GEN	12,855	32.6	0.5	66.9
Tobramycin	TOB	9,276	25.6	3.6	70.8
Ciprofloxacin	CIP	13,526	36.5	1.7	61.8

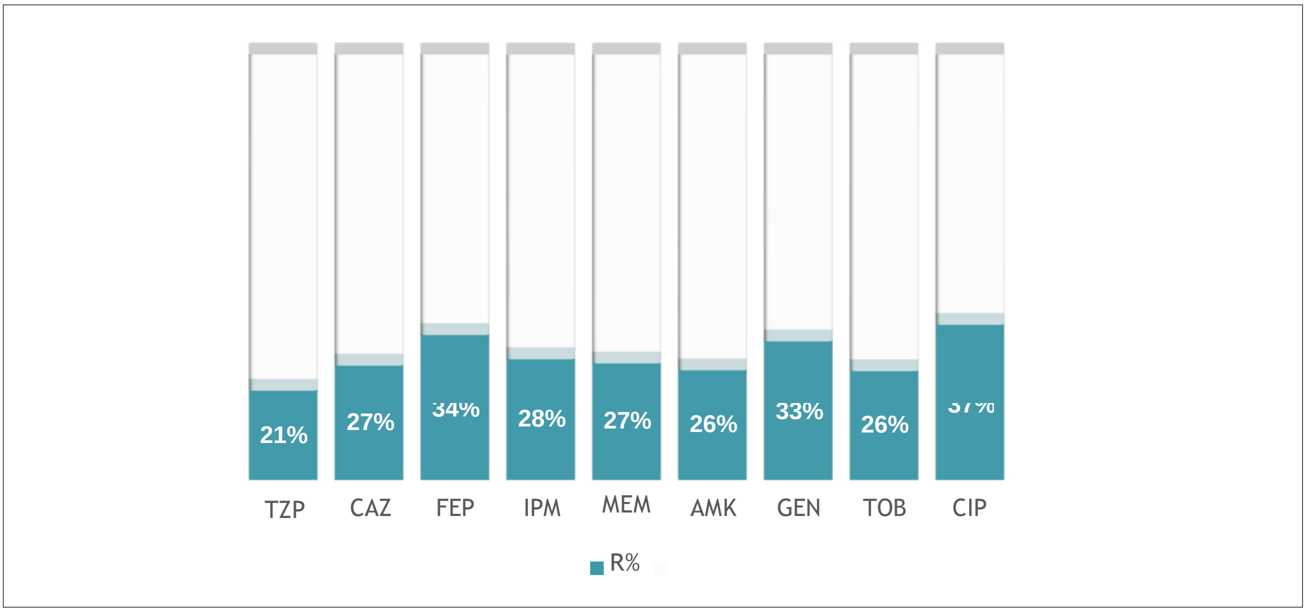


Figure 4.9: Percentages of resistant isolates for *Pseudomonas aeruginosa*, isolates from all sources, Pakistan, 2022

4.4 *Staphylococcus aureus*:

In the year 2022, a total of 23,087 isolates of *Staphylococcus aureus* were reported. The majority of these isolates were from pus specimens, accounting for 55% (n=12,624) of the total, followed by blood samples at 16% (3,584). Regarding age distribution, it is more prevalent among males, constituting 55% (n=12,723) of the cases. In age wise distribution, a higher proportion of cases observed in age group of (15-34 years).

Among these, the most tested and reported antimicrobials are oxacillin (74%), clindamycin (78%), erythromycin (74%), and trimethoprim-sulfamethoxazole (69%) of isolates from all specimen sources. *Staphylococcus aureus* showed resistance ranging from 0% for vancomycin to 76% for ciprofloxacin. Additionally, resistance against oxacillin is 66%, and for cefoxitin, it is 68%.

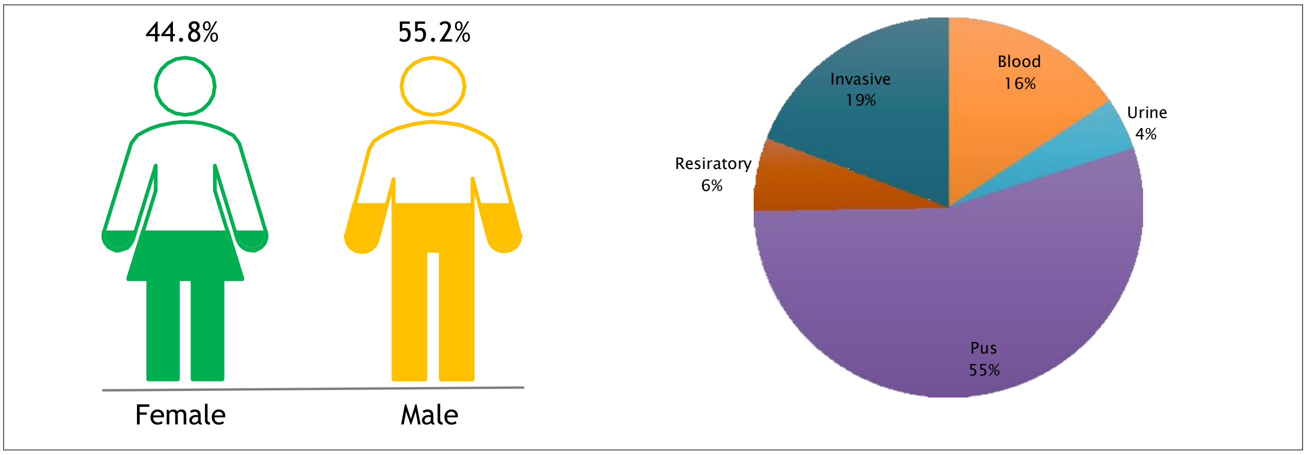


Figure 4.10: *Staphylococcus aureus*: proportion of isolates among different specimen types & gender wise, 2022

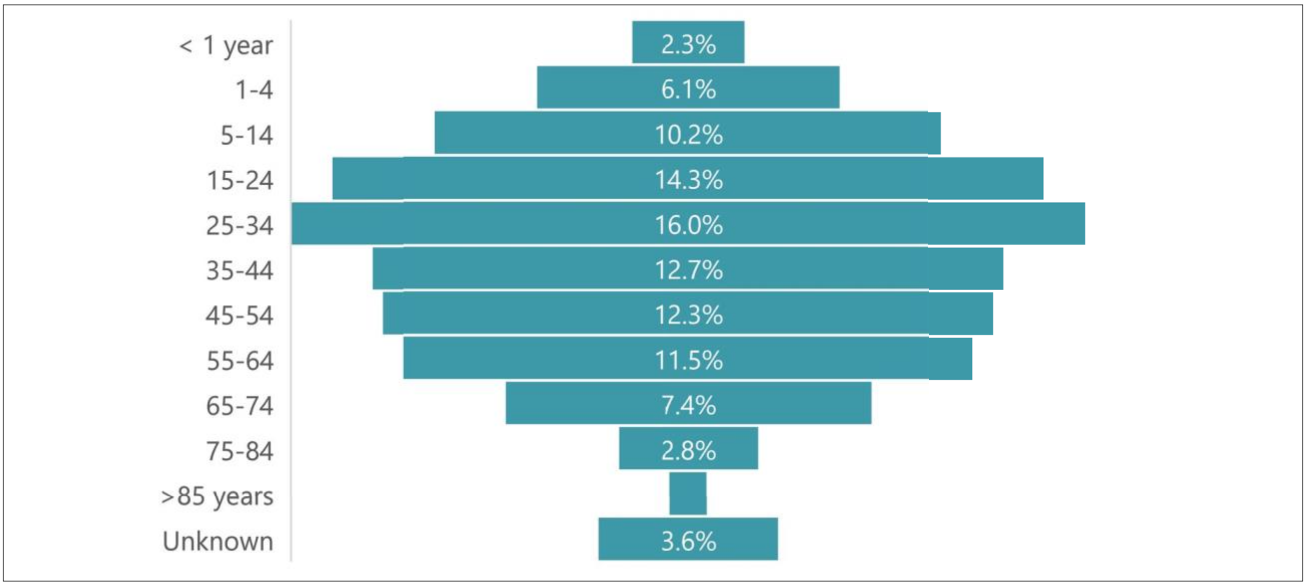


Figure 4.11: *Staphylococcus aureus*: Age wise distribution, 2022

Table 4.4: Percentages of resistant, intermediate, and susceptible isolates for *staphylococcus aureus* isolates from all sources, Pakistan, 2022

Staphylococcus aureus (n=20,633)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Oxacillin	OXA	15,182	66.0	0.0	35.0
Cefoxitin	FOX	3,676	67.7	0.1	32.2
Amikacin	AMK	5,932	9.9	0.5	89.7
Gentamicin	GEN	12,152	25.2	0.4	74.3
Rifampin	RIF	1,747	3.5	0.2	96.3
Ciprofloxacin	CIP	13,928	76.0	0.6	23.4
Levofloxacin	LVX	3,128	74.3	1.3	24.4
Moxifloxacin	MFX	875	55.2	3.7	41.1
Trimethoprim/Sulfamethoxazole	SXT	15,811	27.6	0.3	72.1
Clindamycin	CLI	17,936	23.1	1.7	75.2
Erythromycin	ERY	17,166	63.7	1.3	35.0
Linezolid	LNZ	14,471	0.7	0.1	99.2
Vancomycin	VAN	14,501	0	0	100
Tigecycline	TGC	1,188	1.8	0.5	97.7

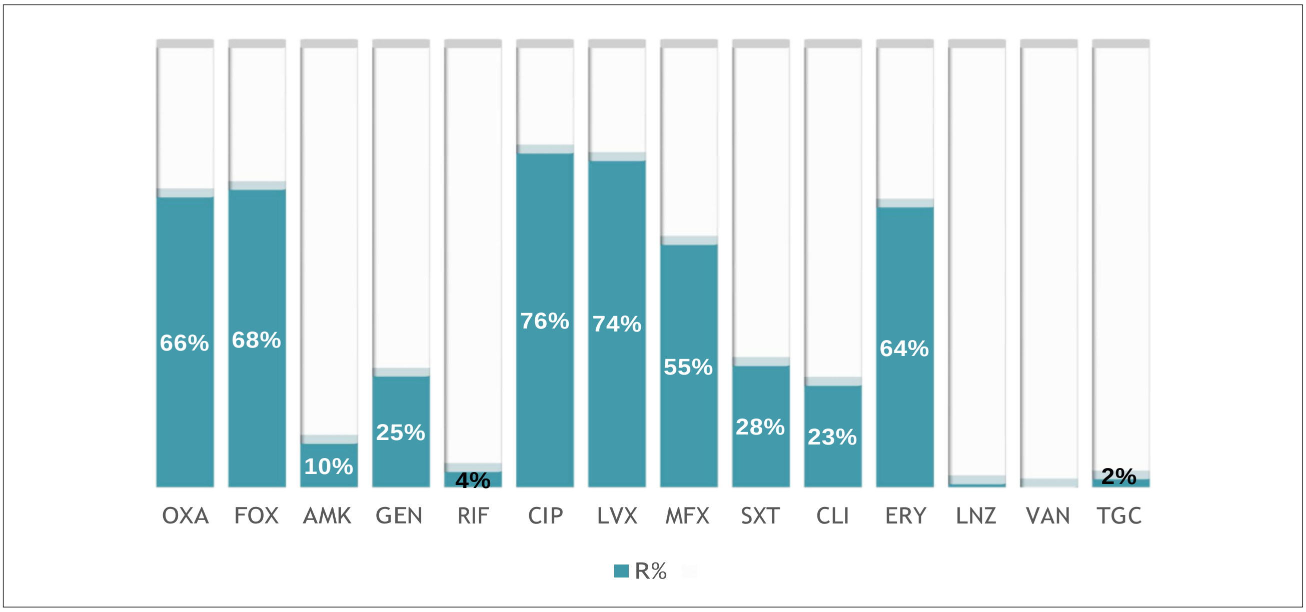


Figure 4.12: Percentages of resistant isolates for *staphylococcus aureus* isolates from all sources, Pakistan, 2022

4.5 *Salmonella* Typhi:

In the year 2022, a total of 26 sentinel sites reported 16,418 isolates of *Salmonella* Typhi. *Salmonella Typhi* is predominantly associated with bloodstream infections, with a higher prevalence among males (n=9,910, 60.4%) compared to females. The age distribution follows a typical pattern, with typhoid infection being more common in younger age groups. Data reveals that over 44% (n=7,243) of isolates are reported from the age group of 1-14 years, with 28% (n=4,605) specifically from the 1-4 age bracket.

Among these, the most tested and reported antimicrobials are Ceftriaxone (98%), Ampicillin (97%), Cefixime (92%), Azithromycin (90%), Ciprofloxacin (83%), Trimethoprim-sulfamethoxazole (82%), and Chloramphenicol (80%) of isolates from all specimen sources.

S. Typhi isolates showed high-level resistance to the first-line antibiotics (Ampicillin 82.6%, Chloramphenicol 81%, Trimethoprim-sulfamethoxazole 79%) previously used for the treatment of typhoid. Similarly, 76% of isolates are resistant to Ciprofloxacin, and 72% are resistant to Ceftriaxone.

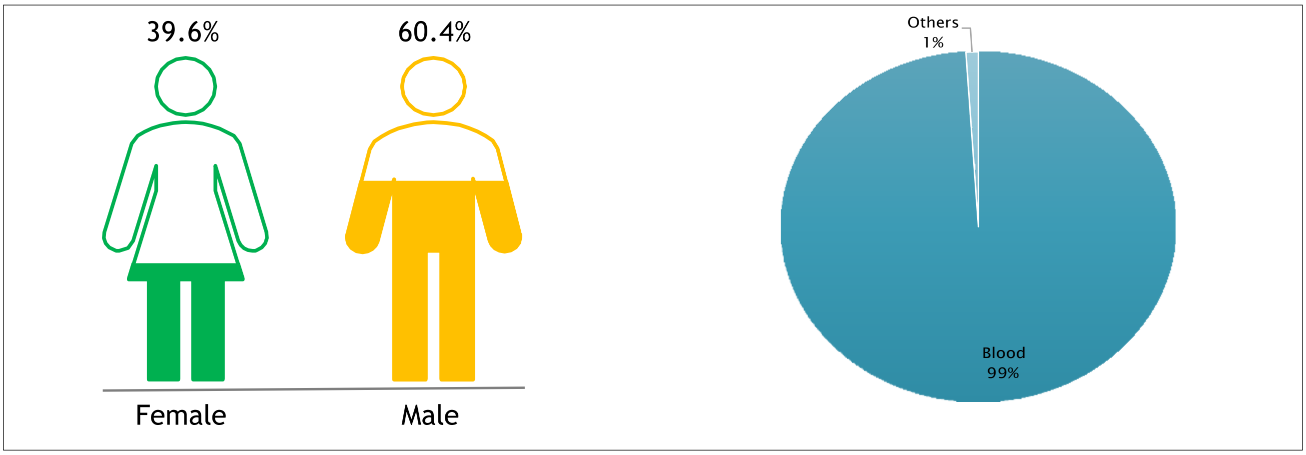


Figure 4.13: *Salmonella* Typhi: proportion of isolates among different specimen types, 2022

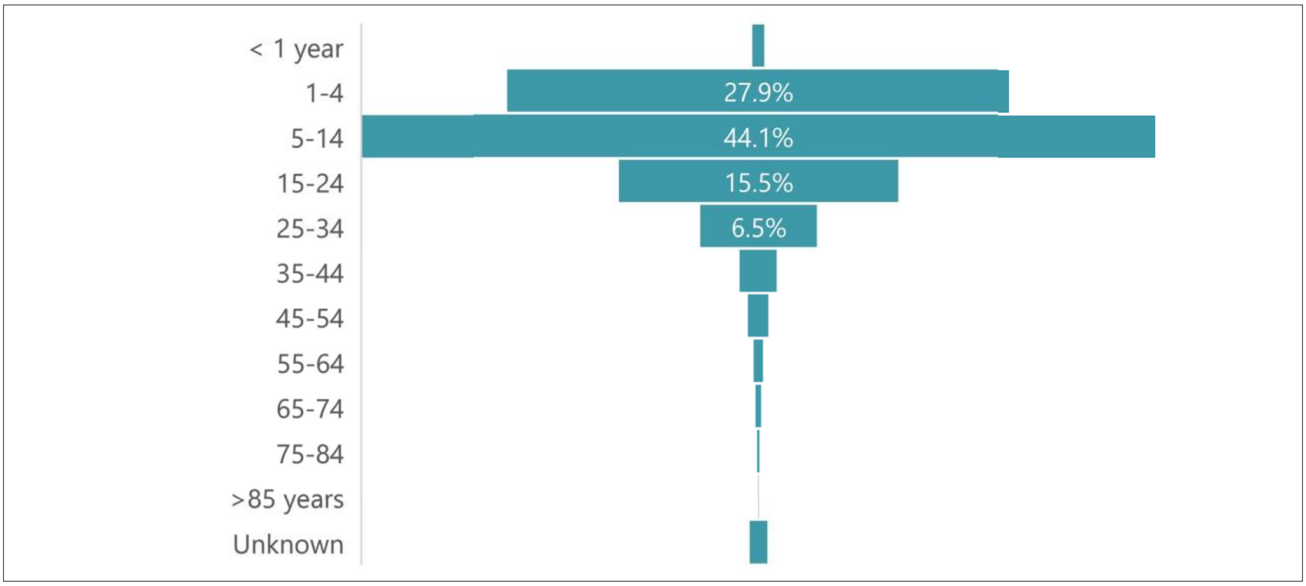


Figure 4.14: *Salmonella* Typhi: gender wise Distribution, 2022

Table 4.5: Percentages of resistant, susceptible and intermediate isolates for *Salmonella* Typhi, isolates from all sources, Pakistan, 2022

Salmonella Typhi (n=16,418)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	15,943	82.6	0.0	17.4
Ceftriaxone	CRO	16,121	72.4	0.1	27.5
Cefotaxime	CTX	580	61.2	0.3	38.4
Cefixime	CFM	15,085	71.9	0.0	28.1
Imipenem	IPM	8,728	0.0	0.0	100
Meropenem	MEM	8,801	0.0	0.0	100
Ciprofloxacin	CIP	13,629	76.1	21.5	2.4
Levofloxacin	LVX	311	64.6	3.9	31.5
Trimethoprim/Sulfamethoxazole	SXT	13,392	79.4	0.0	20.6
Azithromycin	AZM	14,702	1.9	0.0	98.1
Chloramphenicol	CHL	13,150	81.4	0.0	18.6

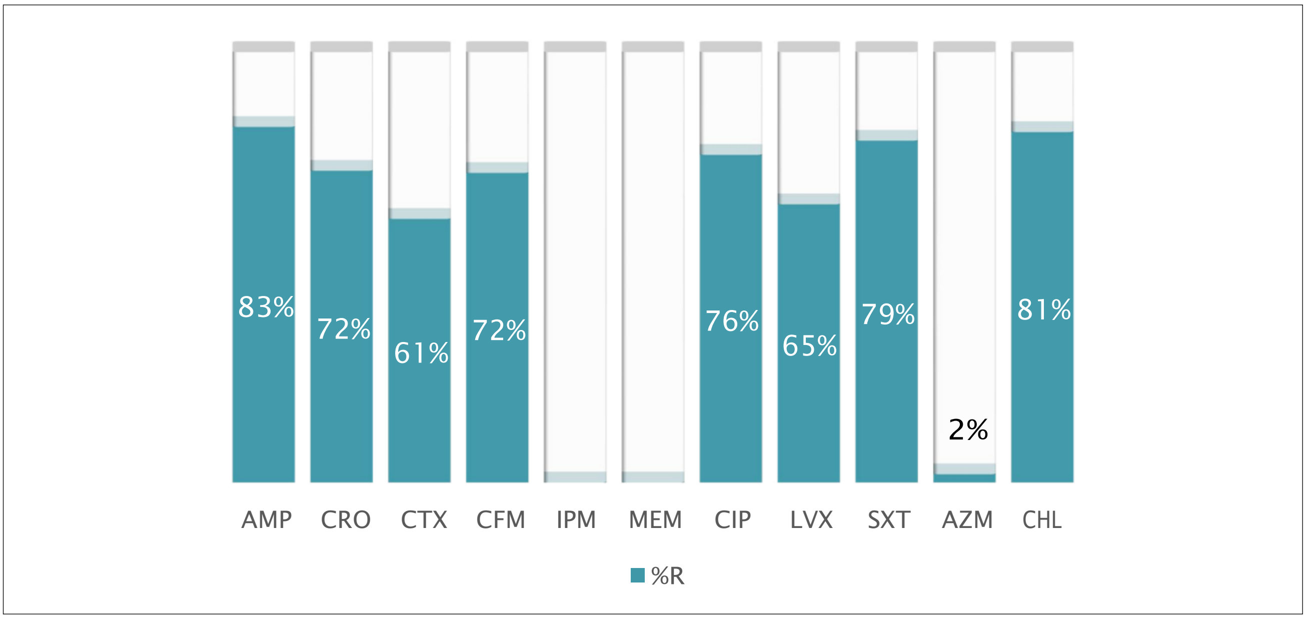


Figure 4.15: Percentages of resistant isolates for *Salmonella* Typhi, isolates from all sources, Pakistan, 2022

4.6 *Acinetobacter species:*

In the year 2022, a total of 9,685 isolates of *Acinetobacter* species were reported. More than 45% (n=3,172) of the *Acinetobacter spp.* were isolated from blood specimens, followed by respiratory samples at 24% (n=1,711). The prevalence is higher in male patients (n=4,121) compared to females. Age-wise distribution doesn't show any significant variation among age categories.

Among these, the most tested and reported antimicrobials are Amikacin in 92%, Gentamicin at 82%, Meropenem and Imipenem at 76% and 74% respectively, Piperacillin-tazobactam in 63%, and colistin in 58% of isolates from all specimen sources. *Acinetobacter spp* isolates showed a high level of resistance to the antibiotics reported, ranging from 99% against ampicillin, 98% resistance to Amoxicillin-clavulanic acid, ceftriaxone at 89%, and ceftazidime at 85%. Likewise, resistance in carbapenems (Imipenem and Meropenem) is 74% to 73%.

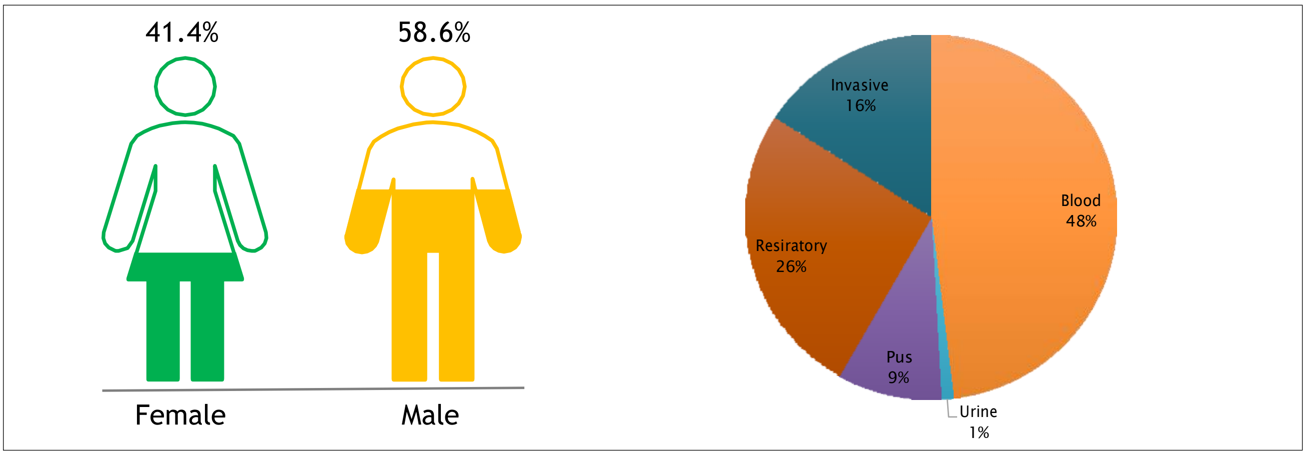


Figure 4.16: *Acinetobacter species*: proportion of isolates among different specimen types, 2022

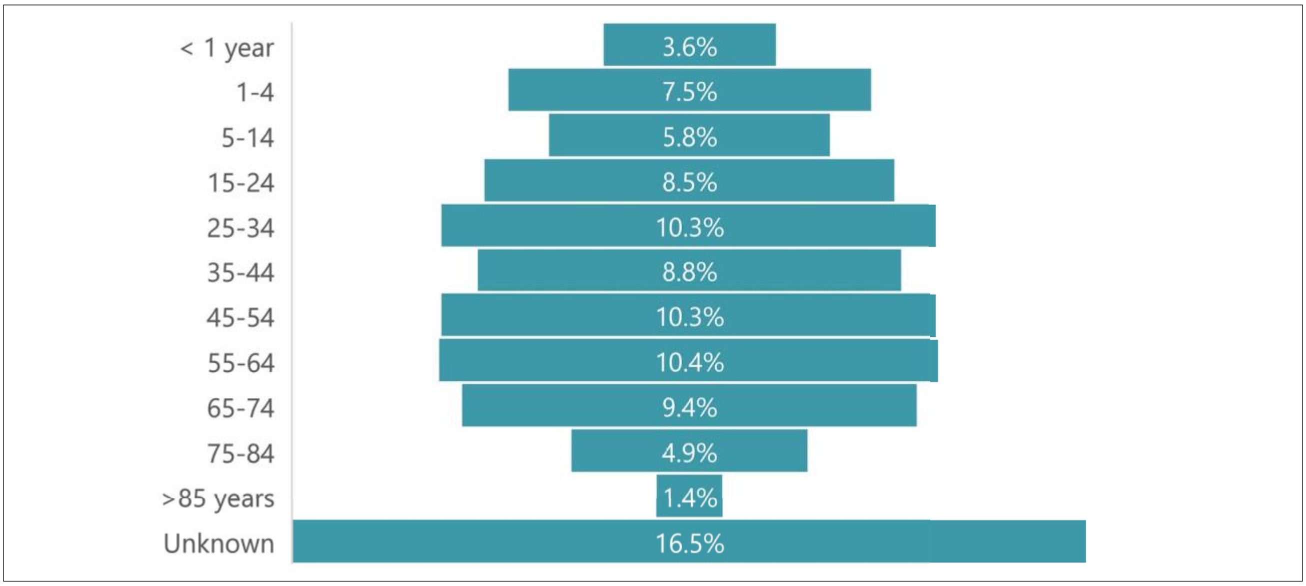


Figure 4.17: *Acinetobacter species*: age wise Distribution, 2022

Table 4.6: Percentages of resistant, intermediate, and susceptible isolates for *Acinetobacter spp.*, isolates from all sources, Pakistan, 2022

Acinetobacter Spp (n=9,685)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	943	99.2	0.1	0.7
Amoxicillin/Clavulanic acid	AMC	977	98	0.1	1.9
Piperacillin /tazobactam	TZP	6,508	75	0.7	24.2
Ceftazidime	CAZ	4,433	85	0.5	14.5
Ceftriaxone	CRO	3,758	89	0.6	10.3
Cefepime	FEP	3,525	83	0.7	16.2
Imipenem	IPM	7,336	74	0.8	25.3
Meropenem	MEM	7,455	73	0.9	26.5
Amikacin	AMK	8,712	64	1.8	34.0
Gentamicin	GEN	8,001	60	3.3	37.1
Ciprofloxacin	CIP	5,871	79	0.8	19.7
Trimethoprim/Sulfamethoxazole	SXT	5,350	73	0.3	27.2
Doxycycline	DOX	2,185	32	0.5	67.7
Minocycline	MNO	3,262	9	3.0	88.3
Tigecycline	TGC	2,452	28	10.3	61.3

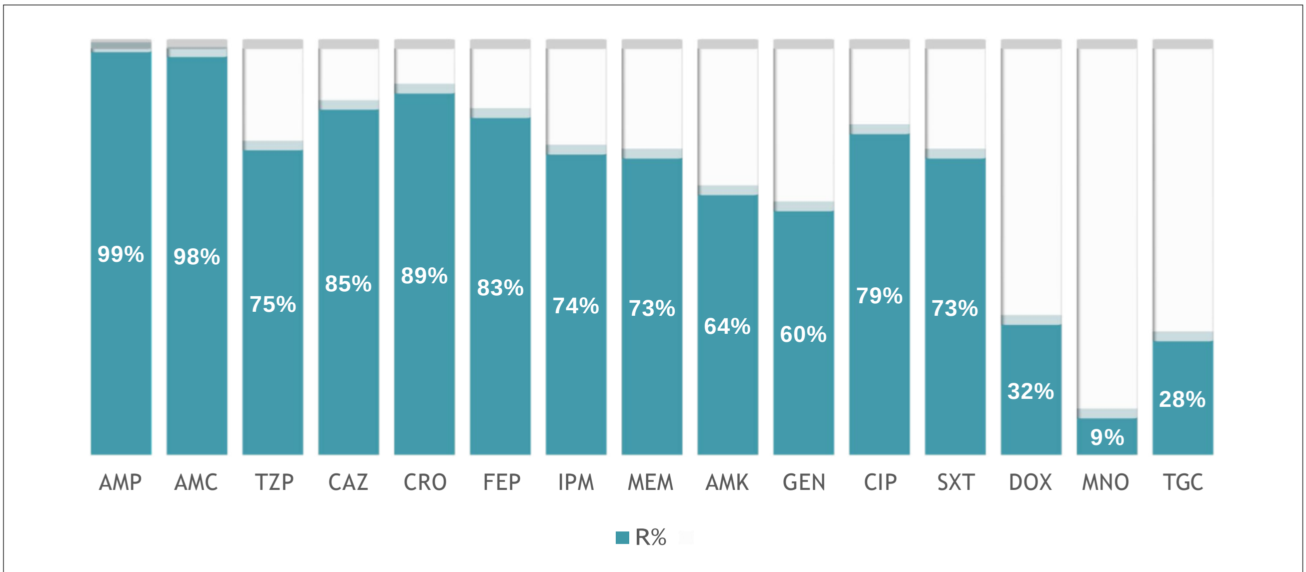


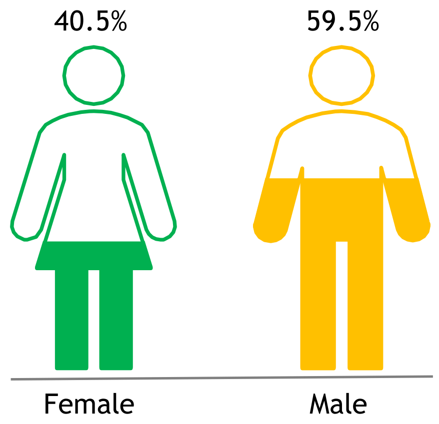
Figure 4.18: Percentages of resistant isolates for *Acinetobacter spp.*, isolates from all sources, Pakistan, 2022

4.7 *Streptococcus pneumoniae:*

In the year 2022, a total of 788 isolates of *Streptococcus pneumoniae* were reported. *Streptococcus pneumoniae* is predominantly isolated from the blood and invasive specimen category. The prevalence is comparatively higher in male patients, accounting for 60% (n=469). The age-wise distribution shows a comparatively higher frequency in the children age group of 1-14 years (n=200) and the older age group of 55-64 years (n=182).

Among these, the most tested and reported antimicrobials are ceftriaxone 71%, Penicillin G 68.7 %, and Trimethoprim-Sulfamethoxazole 66% isolates from all specimen sources.

Resistance to *Streptococcus pneumoniae* ranged from 0% for vancomycin and linezolid 74% for Trimethoprim-Sulfamethoxazole. Around 46% and 43% resistance against erythromycin and Tetracycline respectively.



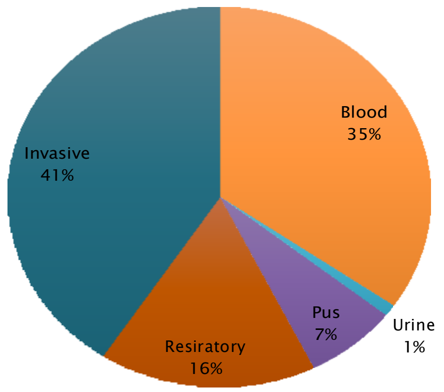


Figure 4.19: *Streptococcus pneumoniae:* proportion of isolates among different specimen types, 2022

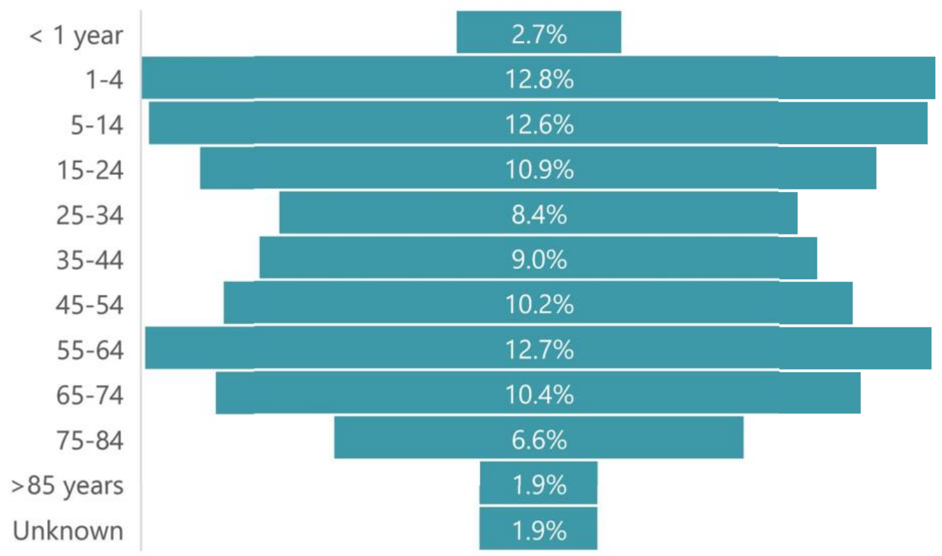


Figure 4.20: *Streptococcus pneumoniae:* gender wise Distribution, 2022

Table 4.7: Percentages of resistant, intermediate, and susceptible isolates for *Streptococcus pneumoniae*, isolates from all sources, Pakistan, 2022

Streptococcus pneumoniae (n=788)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Penicillin G	PEN	541	43.4	0	53.0
Ampicillin	AMP	289	5.2	0.7	94.1
Ceftriaxone	CRO	558	2.7	0.2	94.3
Ciprofloxacin	CIP	21	23.8	4.8	71.4
Levofloxacin	LVX	323	8.0	0	92.0
Trimethoprim/Sulfamethoxazole	SXT	521	73.9	2.1	24.0
Clindamycin	CLI	363	27.8	0.6	71.6
Erythromycin	ERY	325	46.2	0.3	53.5
Linezolid	LNZ	93	0	0	100
Vancomycin	VAN	289	0	0	100
Tetracycline	TCY	242	43.0	1.7	55.4

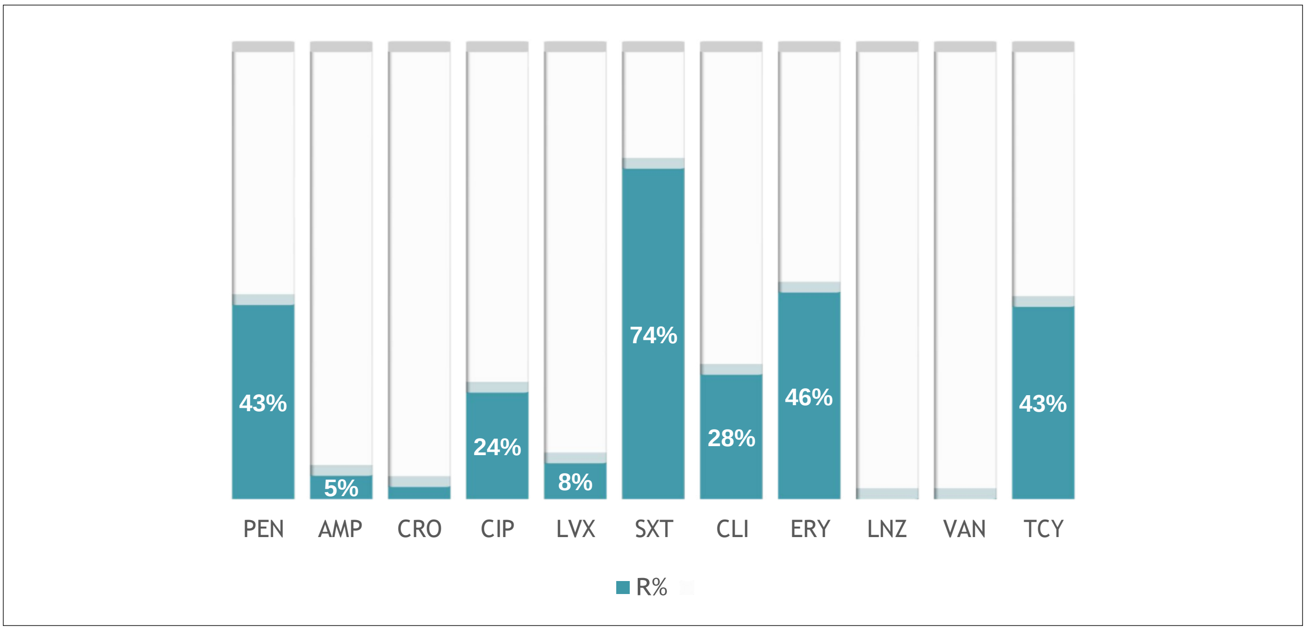


Figure 4.21: Percentages of resistant isolates for *Streptococcus pneumoniae,* isolates from all sources, Pakistan, 2022

4.8 *Neisseria gonorrhoeae*:

In 2022, a total of 50 isolates of *Neisseria gonorrhoeae* were reported. The usual trend persists, with over 95% of isolates originating from urethral swabs. Prevalence is notably higher in the adult age group of 25-34 years, accounting for 27 cases.

Among these, the most tested and reported antimicrobials are ceftriaxone and ciprofloxacin, cefixime, and azithromycin, tested across all specimen sources.

In the year 2022, *Neisseria gonorrhoeae* isolates showed a 90% resistance rate to ciprofloxacin. However, isolates remained sensitive to ceftriaxone and cefixime.

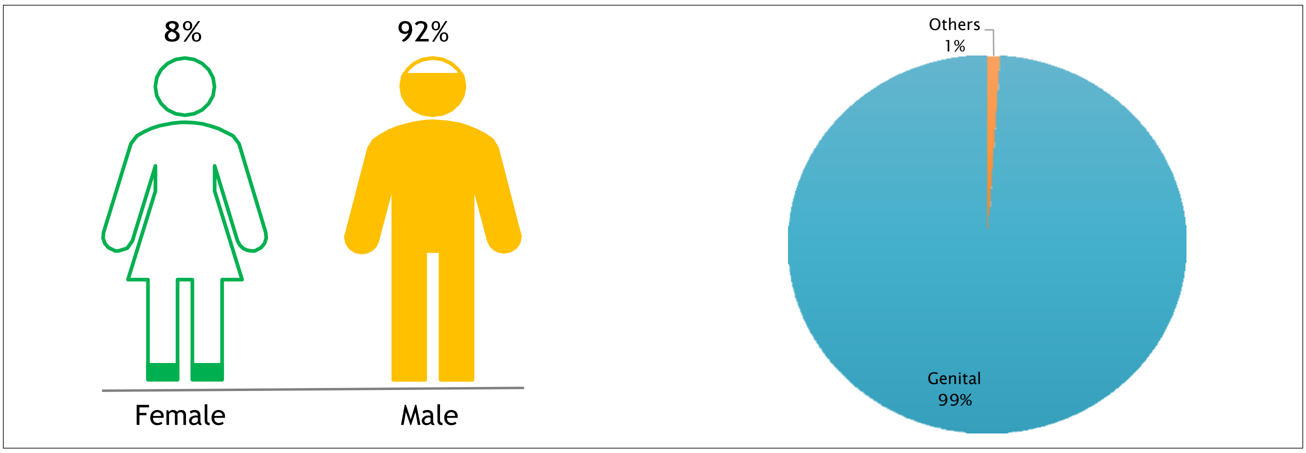


Figure 4.22: *Neisseria gonorrhoeae*: proportion of isolates among different specimen types, 2022

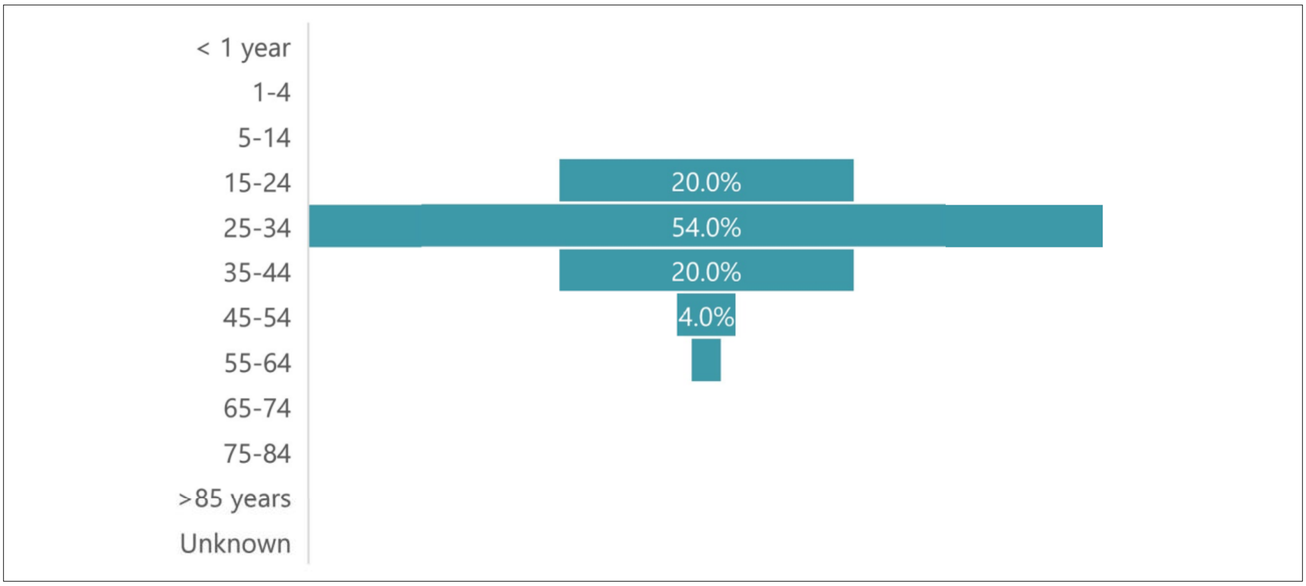


Figure 4.23: *Neisseria gonorrhoeae*: gender wise Distribution, 2022

Table 4.8: Percentages of resistant, intermediate, and susceptible isolates for *Neisseria gonorrhoeae*, isolates from all sources, Pakistan, 2022

Neisseria gonorrhoeae (n=50)					
Antibiotic	Code	Isolates(n)	R%	I%	S%
Ceftriaxone	CRO	41	0	0	100
Cefixime	CFM	40	0	0	100
Spectinomycin	SPT	4	0	0	100
Ciprofloxacin	CIP	40	90	5	5
Azithromycin	AZM	39	0	0	100

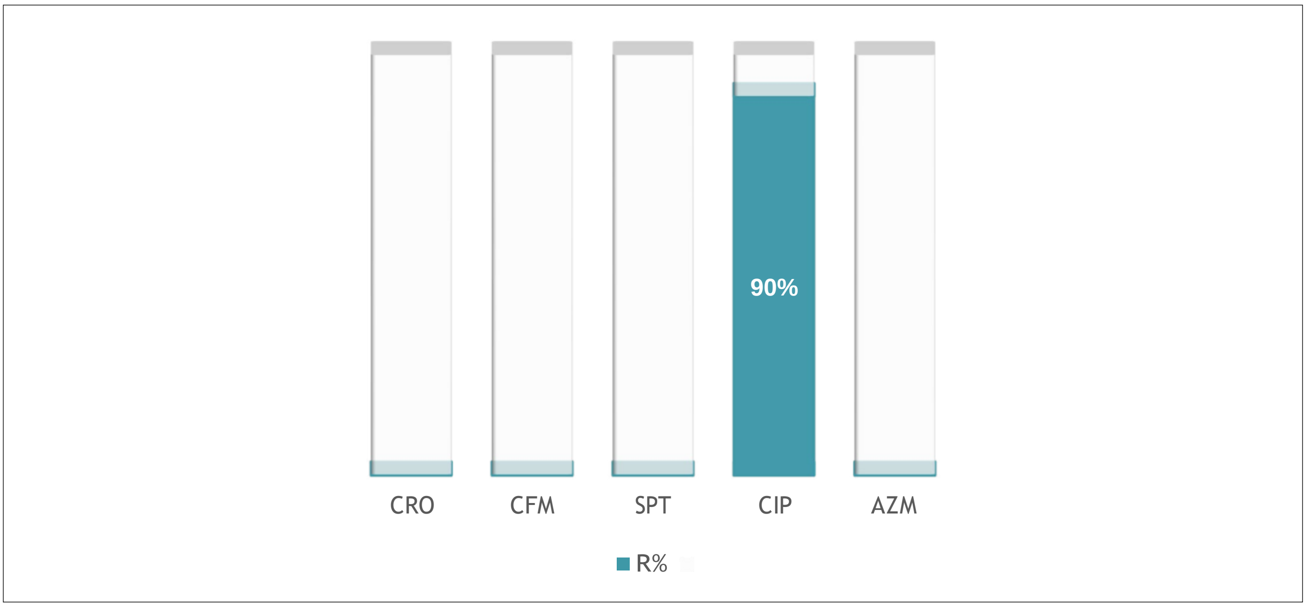


Figure 4.24: Percentages of resistant isolates for *Neisseria gonorrhoeae*, isolates from all sources, Pakistan, 2022

4.9 *Shigella species*:

In 2022, a total of 166 isolates of *Shigella spp* were reported. The majority of these isolates were from stool samples, comprising around 82%, while approximately 9% were from blood samples. In terms of age distribution, the under-15 age group exhibited a higher number of cases compared to the elder age group.

The most tested and reported antimicrobials among these are ciprofloxacin, ceftriaxone, and azithromycin, tested across all isolates from various specimen sources. *Shigella spp* isolates exhibit 85% and 78% resistance to ampicillin and trimethoprim-sulfamethoxazole, respectively. Additionally, 29% of isolates demonstrate resistance to ciprofloxacin. Carbapenems remain effective against all reported isolates.

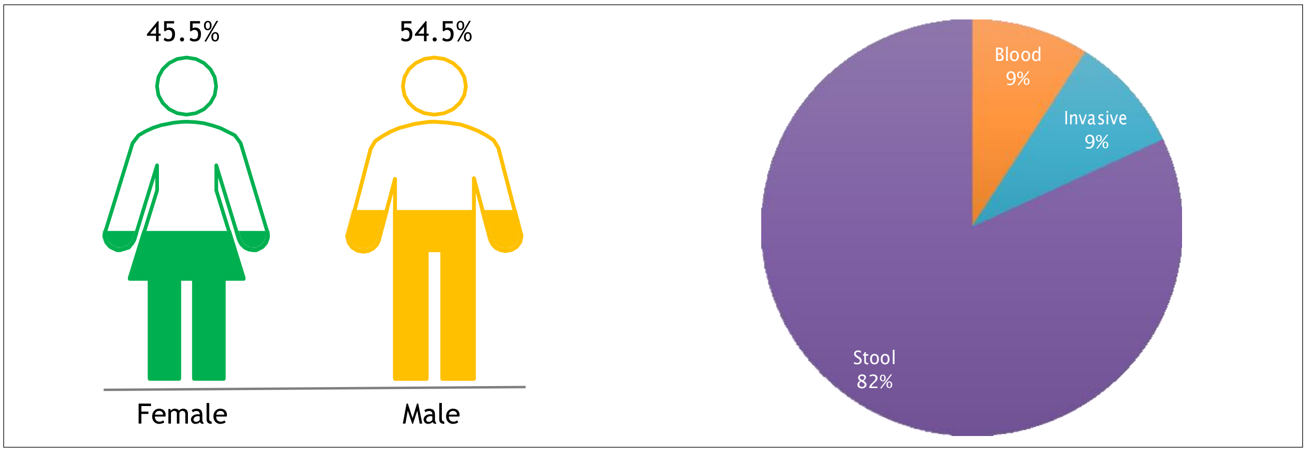


Figure 4,25: *Shigella species*: proportion of isolates among different specimen types, 2022

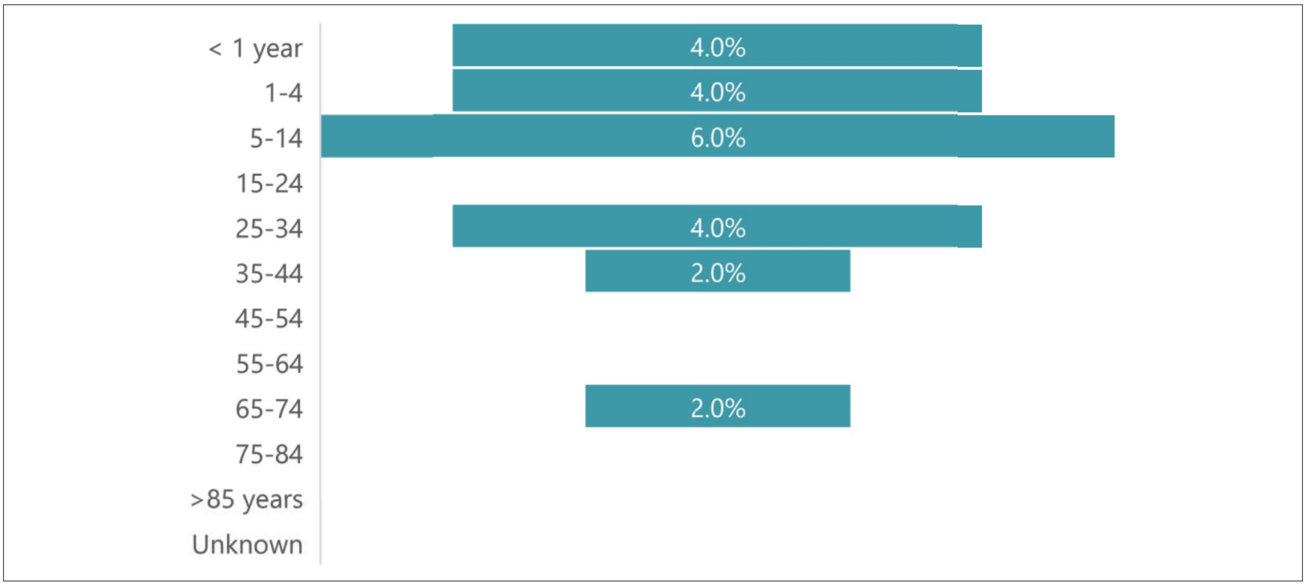


Figure 4.26: *Shigella species*: gender wise Distribution, 2022

Table 4.9: Percentages of resistant, intermediate, and susceptible isolates for *shigella spp*. isolates from all sources, Pakistan, 2022

Shigella spp (n=166)					
Antibiotic	Code	Isolates(n)	%R	%I	%S
Ampicillin	AMP	68	85.3	0	14.7
Ceftriaxone	CRO	103	74.8	0	25.2
Imipenem	IPM	47	0	0	100
Meropenem	MEM	34	0	0	100
Ciprofloxacin	CIP	158	28.5	20.9	50.6
Trimethoprim/Sulfamethoxazole	SXT	72	77.8	0	22.2
Azithromycin	AZM	108	13.9	0	86.1
Chloramphenicol	CHL	46	17.4	0	82.6

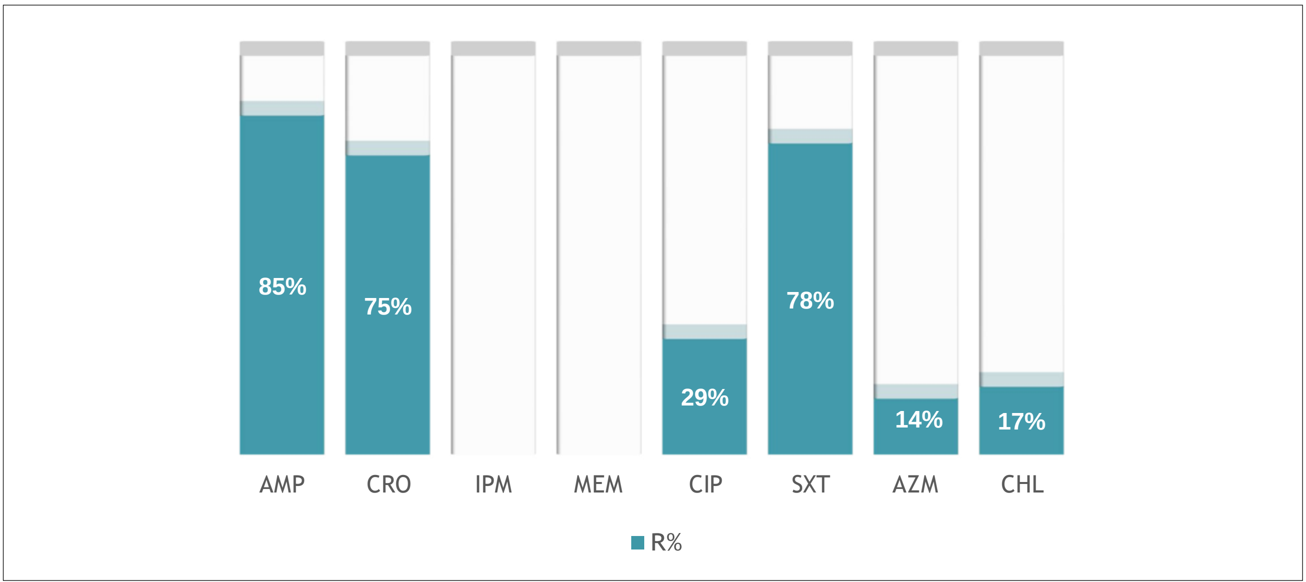


Figure 4.27: Percentages of resistant isolates for *shigella spp* isolates from all sources, Pakistan, 2022

4.10 MDR, XDR & PDR summary, Pakistan-2022:

Table 4.10: MDR, XDR & PDR summary, 2022

Organism	Number of isolates	MDR	Possible XDR	Possible PDR
E. coli	82679	42277(51%)	12082(14.6%)	1770(2.1%)
Klebsiella pneumoniae	27617	14012(50.7)	8404(30.4%)	1826(6.6%)
Staphylococcus aureus	23087	12423(53.8%)	1863(8.1%)	(0%)
Pseudomonas aeruginosa	17263	4664(27.0%)	4335(25.1%)	1771(10.25%)
Salmonella Typhi	16418	9221(56.16%)	7156(43.58%)	0(0%)
Acinetobacter sp.	7027	5038 (71.7%)	4853(69.1%)	1204(17.13%)
Streptococcus pneumoniae	788	0(0%)	0(0%)	0(0%)
Total	174,879	87,635	38,693	6,592

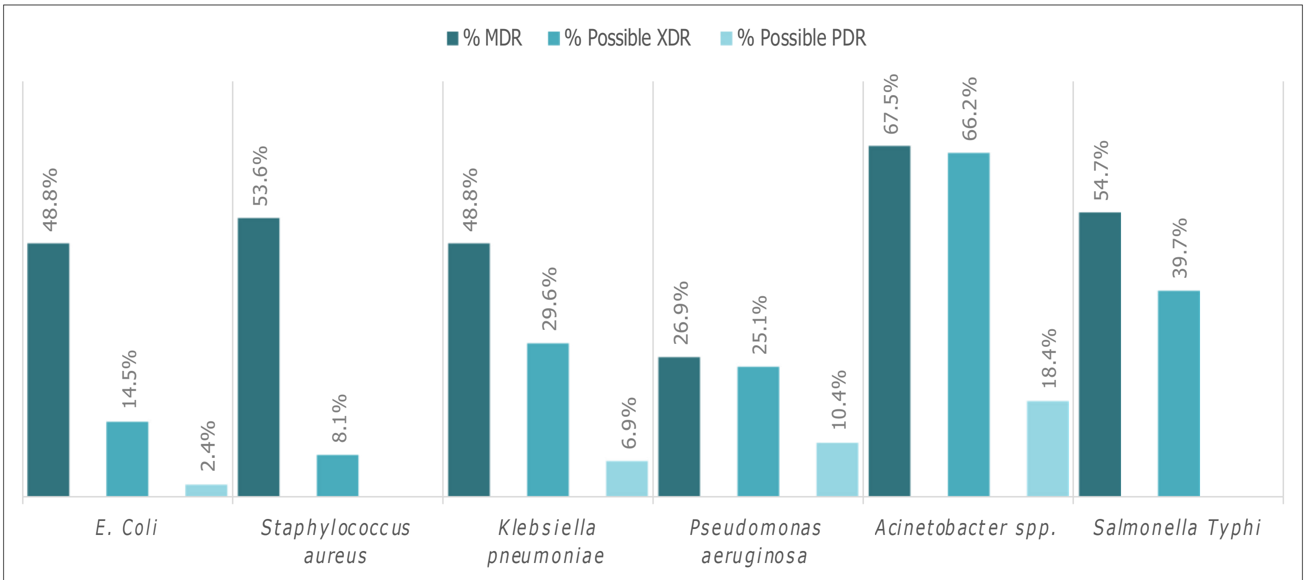


Figure 4.28: MDR, XDR & PDR summary, 2022

5. Limitations and challenges:

1. Inconsistencies in data sharing formats and incomplete data across various sentinel sites pose significant challenges. Furthermore, there is a lack of standardized methods for testing certain antibiotics, particularly those requiring MIC testing for antimicrobial susceptibility.
2. Timely reporting of antimicrobial resistance (AMR) data is hindered by delays in submission to the National Coordination Centre (NCC), leading to further delays in data compilation and analysis for the national AMR report.
3. Currently, only isolate-based surveillance data is available, providing information solely on laboratory-confirmed infections caused by specified target pathogens. However, this approach limits the ability to conduct sample-based or population-based analysis of the AMR burden, as it excludes data on the broader population with suspected infections from whom clinical specimens are not available.
4. Additionally, crucial demographic parameters such as location type and specialty/department are frequently missing from the data, precluding their inclusion in the data analysis process.
5. Use of digital platform for data collection and analysis for timely reporting and ensuring data quality

6. Conclusion:

- The National AMR Surveillance Report highlights the ongoing efforts and achievements of the surveillance system in estimating the burden of AMR in Pakistan. Through effective data collection, analysis, and dissemination, the system has played a crucial role in informing evidence-based decision-making, raising awareness, and implementing interventions to combat AMR. By continuing to strengthen the pillars of the surveillance system and implementing the recommended strategies, Pakistan can further enhance its capacity to tackle the growing threat of AMR and safeguard public health.

- Furthermore, it is imperative to emphasize the importance of continued political commitment and sustained financial investment in AMR surveillance. Adequate resources should be allocated to support the expansion and maintenance of the surveillance system, including the establishment of additional sentinel sites, procurement of advanced laboratory equipment, and recruitment of skilled personnel.

- Sharing data, best practices, and lessons learned can contribute to a comprehensive understanding of AMR at both national and international levels and enable the development of coordinated strategies to combat this global health threat.

- Regular evaluation and monitoring of the surveillance system's performance are essential to ensure its effectiveness and identify areas for improvement. Conducting periodic assessments, engaging in external audits, and seeking feedback from stakeholders can provide valuable insights into the strengths and weaknesses of the system, allowing for timely adjustments and enhancements.

- In conclusion, the National AMR Surveillance Report underscores the significance of the AMR Surveillance System in Pakistan and its contributions to estimating the burden of AMR, informing decision-making, and implementing interventions. By implementing the recommended measures and prioritizing sustained investment, collaboration, and quality improvement, Pakistan can strengthen its ability to combat AMR effectively and safeguard the effectiveness of antimicrobial agents for future generations.

7. Recommendations:

7.1 Recommendations on the surveillance system:

1. Efforts should be directed towards enhancing the representativeness of the data. Currently, there is no differentiation between hospital and community-acquired infections. Data appears to be collected based on the dates of patient admission and specimen collection. Therefore, it should be feasible to distinguish between infections occurring within 48 hours of admission – serving as a proxy for community-acquired cases – and those occurring after 48 hours, which are likely to be healthcare-associated. Without this distinction, especially if a majority of specimens come from ICU or patients with treatment failure, the system is significantly biased and may only be applicable for informing treatment decisions within this specific population, rather than guiding broader guidelines.

2. Concurrently with supporting the laboratory, efforts should be directed towards diagnostic stewardship to ensure appropriate investigation of patients in accordance with clinical needs.

3. The data on urine clearly indicates very high resistance to most drugs except nitrofurantoin and fosfomycin. Nitrofurantoin, listed as the drug of choice in the WHO Antibiotic book, is cheap and falls under the Access category. This gives a very clear indication of the need to widely roll out this guidance and ensure access to effective first-line therapies.

7.2 Recommendations on policy guidance:

1. The levels of resistance for many pathogens, such as Acinetobacter baumannii, are very alarming, highlighting the absolute imperative to strengthen infection control measures and control of multi-drug-resistant organisms in hospitals. It appears that most infections being transmitted are highly resistant and extremely difficult and costly to treat.

2. The high levels of resistance are being driven by inappropriate use of antibiotics at all levels of the health system. Given the very high levels of resistance, for example, to third-generation cephalosporins, their indiscriminate use is a waste of money in most instances, as well as contributing to the problem.

3. Approximately 50% of the specimens in the system are urine samples. Given resource constraints, prioritizing blood cultures would be more prudent, with intermittent urine sampling to monitor any significant changes in susceptibility patterns.

4. Although there is limited information on Streptococcus pneumoniae, it will still be a high-burden pathogen in respiratory infections, and it is encouraging that the data indicates good susceptibility to amoxicillin, the first-line treatment. It is reassuring guidance to clinicians that amoxicillin is still the treatment of choice.

8. Annexures:

Annex I: GLASS Target pathogens and specimen types

Target pathogens	Blood	CSF	Urine	Stool	Lower respiratory tract	Urethral, cervical, rectal, pharyngeal swabs
Acinetobacter spp.	●	○			●	
Escherichia coli	●	○	●		○	
Klebsiella pneumoniae	●	○	●		●	
Pseudomonas aeruginosa	●	○			●	
Staphylococcus aureus	●	○			●	
Streptococcus pneumoniae	●	●			●	
Neisseria meningitidis	●	●				
Haemophilus influenzae	○	●			●	
Salmonella spp. (non-typhoidal)	●	○	●			
S. enterica serovar Typhi	●		○			
S. enterica serovar Paratyphi A	●					
Shigella spp.						
Neisseria gonorrhoeae						●

Annex II: List of Surveillance Sites contributed in year 2021

Sr. #	Province/ Region	Name of sentinel site	Type of sentinel site	Ownership
1	Azad and Jammu Kashmir	Abbas Institute of Medical Science, Muzaffarabad	Hospital	Public Sector
2	Baluchistan	Bolan Medical Complex, Quetta	Hospital	Public Sector
3	Islamabad Capital Territory	Excel Laboratories (>120 collection centers across)	Clinical Laboratory	Private Sector
4		Islamabad Diagnostic Center Laboratories (> 110 collection centers across)	Clinical Laboratory	Private Sector
5		Pakistan Institute of Medical Sciences (PIMS)	Hospital	Public Sector
6		Quaid e Azam International Hospital, Islamabad	Hospital	Private Sector
7		Shifa International Hospital Islamabad	Hospital	Private Sector
8	Khyber Pakhtunkhwa	Peshawar Medical College, Peshawar	Hospital	Private Sector
9		Rehman Medical Complex, Peshawar	Hospital	Private Sector
10	Punjab	Allama Iqbal Medical College, Lahore	Hospital	Public Sector
11		Chugtai Laboratories, Lahore (> 300 collection centers across country)	Clinical Laboratory	Private Sector
12		Mayo Hospital, Lahore	Hospital	Public Sector
13		Shaukat Khanum Hospital, Lahore (>109 collection centers across country)	Hospital	Private Sector
14		Sheikh Zayed Hospital, Lahore	Hospital	Public Sector
15	Sindh	Aga Khan University Hospital, Karachi (>240 collection centers across country)	Hospital	Private Sector
16		Dr. Ruth K. M. Pfau Civil Hospital Karachi	Hospital	Public Sector
17		Jinnah Post Graduate Medical Center, Karachi	Hospital	Public Sector
18		Reliance Laboratories Karachi	Clinical Laboratory	Private Sector
19		PNS Shifa Hospital, Karachi	Hospital	Public Sector

Annex III: List of Surveillance Sites contributed in year 2022

Sr. #	Province/ Region	Name of sentinel site	Type of sentinel site	Ownership
1	Azad and Jammu Kashmir	Abbas Institute of Medical Science, Muzaffarabad	Hospital	Public Sector
2	Baluchistan	Bolan Medical Complex, Quetta	Hospital	Public Sector
3	Gilgit Baltistan	Provincial Headquarter hospital, Gilgit	Hospital	Public Sector
4	Islamabad Capital Territory	Excel Laboratories (>120 collection centers across)	Clinical Laboratory	Private Sector
5		Islamabad Diagnostic Center Laboratories (> 110 collection centers across)	Clinical Laboratory	Private Sector
6		Pakistan Institute of Medical Sciences (PIMS)	Hospital	Public Sector
7		Quaid e Azam International Hospital, Islamabad	Hospital	Private Sector
8		Shifa International Hospital Islamabad	Hospital	Private Sector
9	Khyber Pakhtunkhwa	Peshawar Medical College, Peshawar	Hospital	Private Sector
10		Rehman Medical Complex, Peshawar	Hospital	Private Sector
11		Khyber Teaching Hospital, Peshawar	Hospital	Private Sector
12		Hayatabad Medical Complex, Peshawar	Hospital	Private Sector
13		Saidu Group of Teaching hospitals, Swat	Hospital	Private Sector
14	Punjab	Allama Iqbal Medical College, Lahore	Hospital	Public Sector
15		Chugtai Laboratories, Lahore (> 300 collection centers across country)	Clinical Laboratory	Private Sector
16		Mayo Hospital, Lahore	Hospital	Public Sector
17		Shaukat Khanum Hospital, Lahore (>109 collection centers across country)	Hospital	Private Sector
18		Sheikh Zayed Hospital, Lahore	Hospital	Public Sector
19	Sindh	Aga Khan University Hospital, Karachi (>240 collection centers across country)	Hospital	Private Sector
20		Dr. Ruth K. M. Pfau Civil Hospital Karachi	Hospital	Public Sector
21		Jinnah Post Graduate Medical Center, Karachi	Hospital	Public Sector
22		Reliance Laboratories Karachi	Clinical Laboratory	Private Sector
23		Dow University of Health Sciences Karachi	Hospital	Private Sector
24		Liaquat National Hospital Karachi	Hospital	Private Sector
25		Indus Hospital and Health Network Karachi	Hospital	Private Sector
26		Liaquat University of Medical and Health Sciences, Hyderabad	Hospital	Private Sector

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