EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Coden USA: EJBPBO
Volume: 13
Issue: 8
Year: 2026

DEVELOPMENT OF A CUMULATIVE ANTIBIOGRAM OF BACTERIAL ISOLATES FROM PUS, SPUTUM AND URINE SAMPLES IN A TERTIARY CARE HOSPITAL: A PROSPECTIVE OBSERVATIONAL STUDY

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DOI: https://doi.org/10.5281/zenodo.21884462

How to cite this Article: Gouri Krishna*[1], Anuja Anil[2], Devipriya S.[3], Dr. Akhila S Arjun[4], Dr. Chitra C. Nair[5], Dr. Beena P.[6] (2026). Development Of A Cumulative Antibiogram Of Bacterial Isolates From Pus, Sputum And Urine Samples In A Tertiary Care Hospital: A Prospective Observational Study. European Journal of Biomedical and Pharmaceutical Sciences, 13(8), 401–411.

Article Received on 15/07/2026 **Article Revised on 05/08/2026** **Article Published on 10/08/2026**

ABSTRACT

Antimicrobial resistance (AMR) develops when microorganisms are able to grow and survive in the presence of an antibiotic concentration that is normally sufficient to inhibit or kill them. Antibiotic resistance has become a major global health threat. An antibiogram is a table that summarizes the susceptibility pattern of microorganisms to different classes of antimicrobial agents. This study aimed to create an antibiogram and determine the antibiotic resistance pattern of bacterial strains isolated from pus, sputum, and urine samples. A total of 307 culture sensitivity reports of bacterial isolates were collected from the microbiology department for creating antibiogram. Based on these reports, antibiograms were prepared and the results showed that *Escherichia coli* exhibited high resistance to Ampicillin (76%) followed by Cefazolin (71%), while it showed high sensitivity to Tigecycline (97%) and Meropenem (96%). *Klebsiella species* showed higher resistance to Ampicillin (66%) and Cefazolin (47%) compared to other antibiotics, but high sensitivity to Colistin (94%) followed by Meropenem, Imipenem, and Tigecycline (83%). *Pseudomonas aeruginosa* showed high sensitivity to most tested antibiotics, with maximum sensitivity to Colistin (94%) and Meropenem (92%), but 26% resistance to Ciprofloxacin. *Staphylococcus species* were highly sensitive to Doxycycline and Rifampicin (100%) followed by Vancomycin (97%). *Enterococcus species* showed high sensitivity to Fosfomycin (100%) and Linezolid (93%) but high resistance to Penicillin (93%) and Ampicillin (60%). *Streptococcus species* showed resistance mainly to Penicillin (76%) while remaining highly sensitive to several antibiotics. This study concluded that local antibiograms are valuable tools for guiding appropriate empirical antibiotic therapy by identifying prevailing antimicrobial susceptibility patterns. Continuous surveillance and effective antimicrobial stewardship are essential to combat the growing burden of antimicrobial resistance.

KEYWORDS: Antibiogram, AMR, Enterobacteriaceae, Non-Fermenter group.

INTRODUCTION

Antimicrobial resistance (AMR) has emerged as one of the most serious threats to global public health, compromising the effectiveness of antibiotics and challenging the successful management of infectious diseases. The rapid emergence and dissemination of resistant bacterial pathogens have resulted in increased morbidity, mortality, prolonged hospital stay, treatment failure, and substantial economic burden on healthcare systems worldwide.[1,2] The World Health Organization (WHO) has recognized AMR as a global health priority and has emphasized the urgent need for coordinated surveillance, antimicrobial stewardship, and rational antibiotic use to combat the growing resistance crisis.[2]

The discovery of antibiotics revolutionized modern medicine by significantly reducing deaths associated with bacterial infections and enabling advances in complex surgical procedures, organ transplantation, intensive care, and cancer chemotherapy. However, the widespread and often inappropriate use of antimicrobial agents has accelerated the evolution of resistant microorganisms. Bacteria acquire resistance through various mechanisms, including spontaneous genetic mutations, horizontal gene transfer, enzymatic degradation of antibiotics, alteration of target sites, reduced membrane permeability, and active efflux pumps. These adaptive mechanisms enable microorganisms to survive antimicrobial exposure, limiting therapeutic options and contributing to the emergence of multidrug-resistant pathogens in both hospital and community settings.[3–6]

Healthcare-associated infections and community-acquired bacterial infections continue to pose a major clinical challenge worldwide. The commonly isolated bacterial pathogens are *Escherichia coli*, *Klebsiella* spp., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus* spp., *Enterococcus* spp., and *Streptococcus* spp. These organisms are frequently isolated from clinical specimens such as pus, sputum, and urine, which represent common sites of bacterial infection. The spectrum of bacterial pathogens and their antimicrobial susceptibility profiles vary considerably across geographical regions, healthcare institutions, patient populations, and clinical specimens.[7–10]

Pyogenic wound infections remain an important cause of morbidity because they may delay wound healing, increase the risk of surgical site complications, and prolong hospitalization. Similarly, respiratory tract infections are among the leading causes of morbidity and mortality, particularly in elderly individuals, immunocompromised patients, and those with chronic illnesses. Urinary tract infections are one of the most common bacterial infections encountered in clinical practice and account for a substantial proportion of antibiotic prescriptions worldwide.[8–11]

Culture and antimicrobial susceptibility testing remain the cornerstone for the identification of bacterial pathogens and the selection of appropriate antimicrobial therapy. However, because culture reports generally require 24–48 hours for completion, empirical antibiotics are frequently initiated before microbiological confirmation, particularly in patients with severe infections. Inappropriate empirical therapy resulting from outdated or non-local susceptibility data may contribute to treatment failure, prolonged hospitalization, unnecessary exposure to broad-spectrum antibiotics, increased healthcare expenditure, and further development of antimicrobial resistance. Therefore, continuous surveillance of local antimicrobial susceptibility patterns is essential for guiding empirical therapy and promoting the rational use of antibiotics.[11–13]

An antibiogram is a cumulative summary of antimicrobial susceptibility data generated from clinically significant bacterial isolates recovered within a healthcare institution over a defined period. It provides the percentage susceptibility of bacterial pathogens to commonly used antimicrobial agents and serves as an important epidemiological tool for monitoring local resistance trends.[13–15]

Since bacterial resistance patterns continuously evolve under selective antimicrobial pressure, regular surveillance is necessary to ensure that empirical treatment protocols remain clinically relevant and effective. Institution-specific antibiograms therefore represent an indispensable component of hospital infection control programmes and evidence-based antimicrobial prescribing practices.[13–15]

The present study was undertaken to develop a cumulative antibiogram of clinically significant bacterial isolates recovered from culture-positive pus, sputum, and urine samples in a tertiary care hospital. By evaluating the antimicrobial susceptibility patterns of major bacterial pathogens isolated during the study period, this study aims to generate institution-specific susceptibility data that may facilitate appropriate empirical antibiotic selection, strengthen antimicrobial stewardship initiatives, and contribute to continuous surveillance of antimicrobial resistance.

MATERIALS AND METHODS

Study Site: SH Medical Centre, Kottayam.
Study Design: Prospective observational study.
Study Duration: 6 months.
Inclusion Criteria: All Culture reports of pus, sputum and urine samples showing bacterial growth with antibiotic susceptibility testing results were included in the study.
Exclusion Criteria: Reports with incomplete culture sensitivity data or samples with duplicate bacterial isolates from the same patient were excluded to avoid bias.
Procedure: Bacteria are isolated and identified using standard microbiological procedures. Identification is done based on Gram staining, morphology and other biochemical tests as per CLSI guidelines. The commonly used culture media are MacConkey agar and Blood agar for the identification as well as C/S testing of bacteria. C/S testing is done by Kirby-Bauer disc diffusion method. Various discs as per CLSI guidelines are used for the susceptibility testing. The C/S reports of 307 bacterial isolates were collected for analysis and creating antibiogram. The susceptibility data obtained from the culture sensitivity reports were compiled and categorized according to bacterial groups like Enterobacteriaceae (*Escherichia coli*, *Klebsiella species*, *Proteus mirabilis*, *Proteus vulgaris*), Non-fermenters (*Pseudomonas*

species), Gram-Positive *Staphylococcus* group, Gram-positive *Streptococcus* and *Enterococcus* group. The percentage of sensitivity and resistance for each antibiotic against the isolated organisms was calculated. The antibiogram was prepared by summarizing the percentage susceptibility of each organism to commonly used antibiotics. The data were tabulated to represent the resistance and sensitivity patterns of different bacterial isolates, which helps in guiding empirical antibiotic therapy.

RESULT AND DISCUSSION

Table No. 1: Frequency and percentage distribution according to age group (N = 307).

Age	Frequency (n)	Percentage (%)
0-20	48	15.6
20-60	73	23.7
>60	186	60.7

Inference: This chart illustrates the percentage distribution of pus, sputum and urine infections across different age groups, indicating that the majority (60.7%) occur in patients over 60 years of age. This is probably due to the weekend immune system and anatomical changes of the elderly.

Table No. 2: Frequency and percentage distribution according to gender (N = 307).

Gender	Frequency(n)	Percentage (%)
Female	192	62.4
Male	115	37.6

Inference: Analysis of gender-wise distribution of positive samples indicates a higher prevalence of bacterial infections in females (55%) compared to males (45%).

Table No. 3: Frequency and percentage distribution of bacterial isolates (N=307).

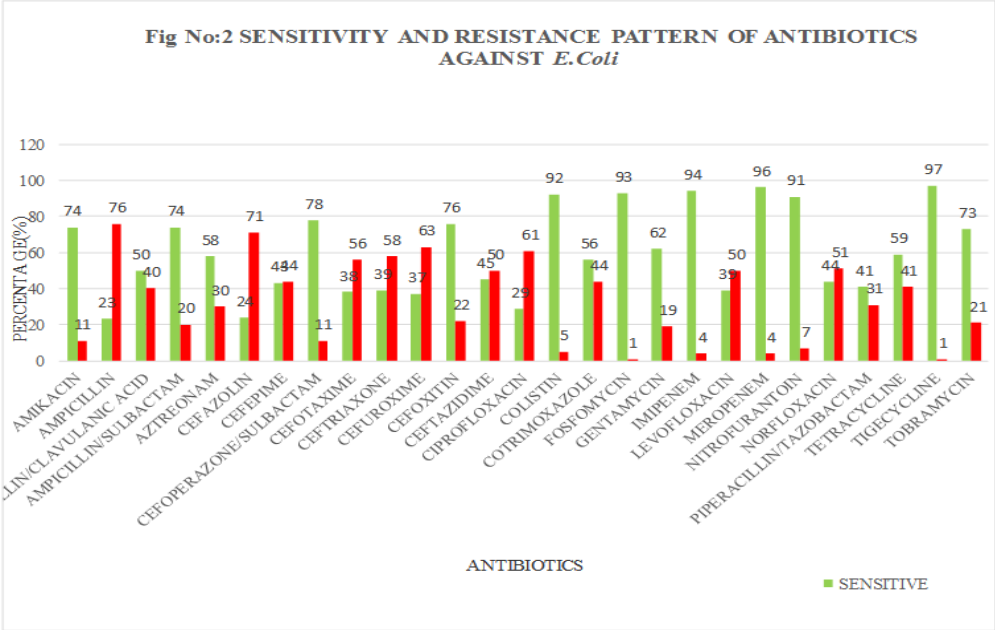
Organism	Frequency(n)	Percentage (%)
Escherichia coli	109	35.5
Klebsiella pneumoniae	65	21.17
Pseudomonas auerogenosa	54	17.59
Streptococcus spp.	19	6.19
Enterococcus spp.	15	4.89
Staphylococcus aureus	36	11.73
Proteus mirabilis	7	2.28
Proteus vulgaris	1	1.2

Inference: This indicates that *Escherichia coli* was the most prevalent bacteria among the isolates.

Fig No: 1-Antibiogram of Enterobacteriaceae group.

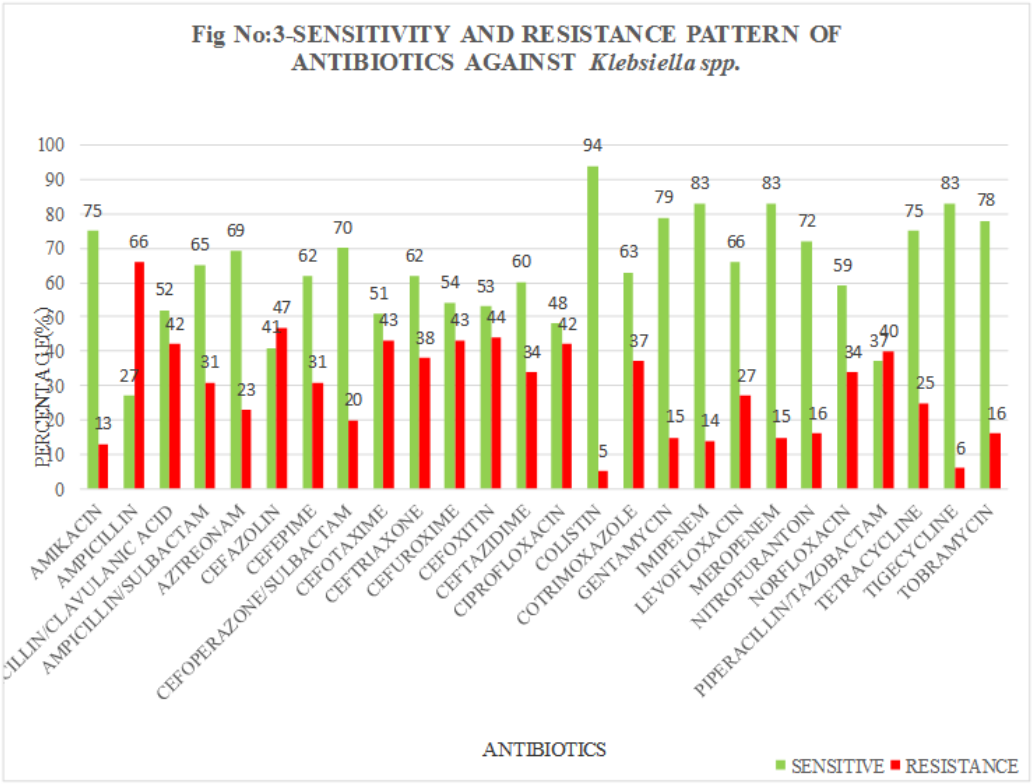
Proteus vulgaris			*Proteus mirabilis*			*Klebsiella spp.*			*Escherichia coli*			Organism
R	M	S	R	M	S	R	M	S	R	M	S	
50		50			100	13	8	75	11	14	74	AMIKACIN
50		50	14		86	6	6	27	7	1	23	AMPICILLIN
50		50		14	86	6	6	52	6	9	50	AMOXYCILLIN/CLAVULANIC ACID
		100			100	3	5	65	2	7	74	AMPICILLIN/SULBACTAM
50		50	17		83	4	8	69	3	12	58	AZTREONAM
100			50	50		7	13	41	0	5	24	CEFAZOLIN
50		50	29		71	1	8	62	7	13	43	CEFEPIME
		100	14		86	2	9	70	1	11	78	CEFOPERAZONE/SALBACTAM
50		50	17		83	0	6	51	5	6	38	CEFOTAXIME
50		50	29		71	4	3	62	6	3	39	CEFTRIAXONE

50		50	29		71	43	3	54	63		37	CEFUROXIME
		100	29		71	44	4	53	22	2	76	CEFOXITIN
50		50	29		71	34	6	60	50	5	45	CEFTAZIDIME
50		50	57		43	42	9	48	61	10	29	CIPROFLOXACIN
100			71		29	5	2	94	5	4	92	COLISTIN
50		50	17		83	37		63	44		56	COTRIMOXAZOLE
									1	6	93	FOSFOMYCIN
50		50			100	15	6	79	19	12	62	GENTAMICIN
	50	50		14	86	14	3	83	4	2	94	IMIPENEM
50		50	33	17	50	27	8	66	50	11	39	LEVOFLOXACIN
	50	50			100	15	2	83	4		96	MEROPENEM
		100	100			16	13	72	7	2	91	NITROFURANTOIN
100					100	34	6	59	51	5	44	NORFLOXACIN
		100			100	40	23	37	31	29	41	PIPERACILLIN/TAZOBACTAM
50		50	100			25		75	41		59	TETRACYCLINE
		100			100	6	11	83	1	2	97	TIGECYCLINE
50		50	14		86	16	6	78	21	6	73	TOBRAMYCIN



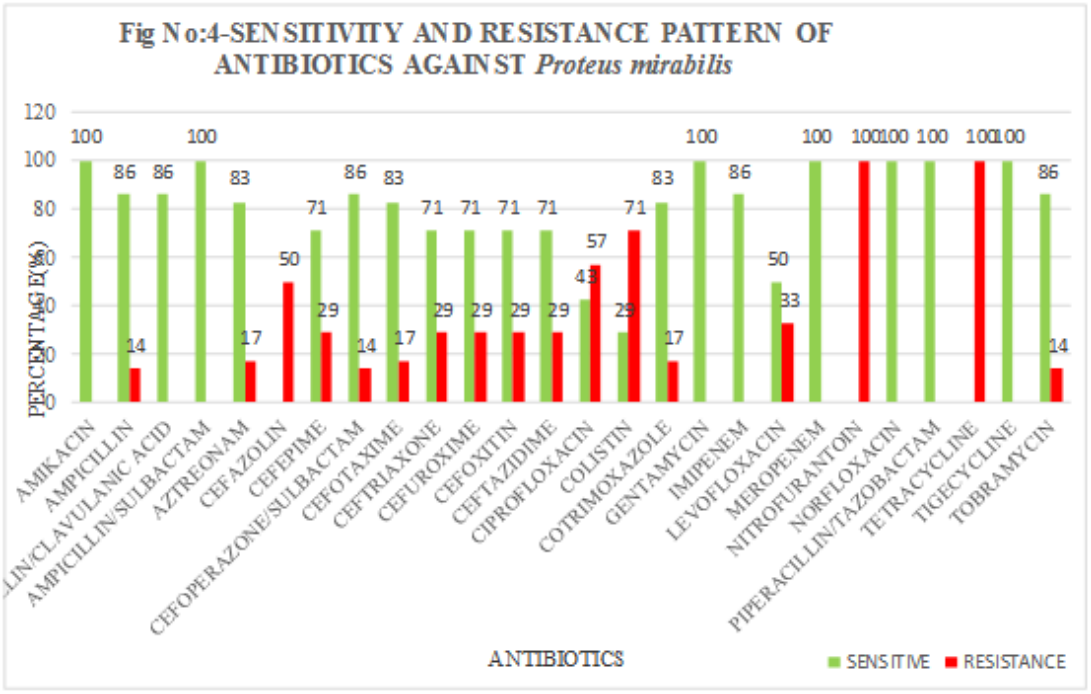
INFERENCE

- *E.Coli* is found to be 76% resistant to Ampicillin, followed by Cefazolin (71%). On the other hand, it is found to be 97% sensitive to Tigecycline followed by Meropenem (96%).
- From the antibiogram of *E.Coli*, the recommended empirical therapy is
  - **1st line: Nitrofurantoin for UTI (91% sensitive) Gentamicin (62% sensitive)**
  - **2nd line: Tobramycin (78% sensitive)**
  - **Restricted (broad spectrum): Tigecycline (97% sensitive)**



INFERENCE

- *Klebsiella* shows more resistance towards Ampicillin (66%) followed by cefazolin (47%) than other antibiotics. It is highly sensitive to Colistin (94%) followed by Meropenem, Imepenem and tigecycline (83%).
- From the antibiogram of *Klebsiella* species, the recommended empirical therapy is
  - **1st line: Gentamicin (79% sensitive)**
  - **2nd line: Fosfomycin for UTI (93% sensitive) Cefoperazone/salbactam (78% sensitive)**
  - **Restricted (broad spectrum): Colistin (94% sensitive)**

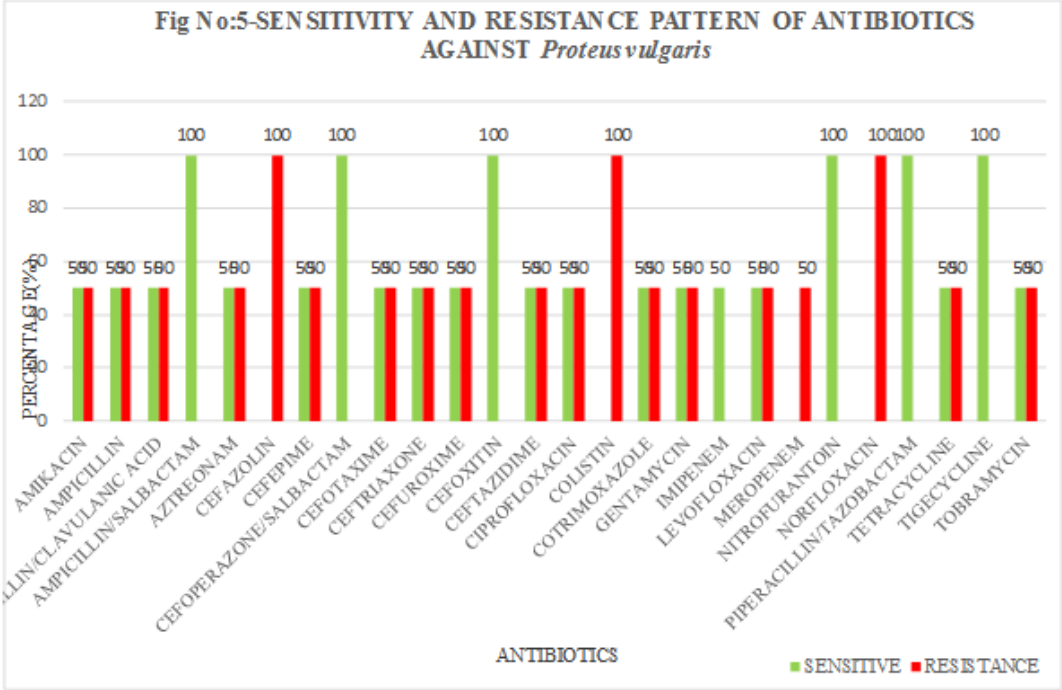


INFERENCE

- Proteus mirabilis shows 100% resistance towards Nitrofurantoin as well as Tetracycline, whereas, shows 100% effective towards Amikacin, Ampicillin/Sulbactam, Gentamicin, Meropenem, Norfloxacin, Piperacillin/Tazobactam and Tigecycline.
- From the antibiogram of Proteus mirabilis organism, the recommended empirical therapy is
- **1st line: Gentamicin (100% sensitive)**

Piperacillin/tazobactam(100% sensitive)
Norfloxacin for UTI (100% sensitive)

- **2nd line: Fosfomycin for UTI (93% sensitive)**
Amikacin (100% sensitive)
- **Restricted (broad spectrum): Meropenem (100% sensitive)**
Tigecycline (100% sensitive)



INFERENCE

- Proteus vulgaris is 100% resistant to Cefazolin, Colistin and Norfloxacin. On the other hand, it is 100% sensitive to Ampicillin/Sulbactam, Cefoperazone/Sulbactam, Cefoxitin, Nitrofurantoin, Piperacillin/Tazobactam and Tigecycline.
- From the antibiogram of Proteus vulgaris, the recommended empirical therapy is
- **1st line : Nitrofurantoin for UTI (100% sensitive)**

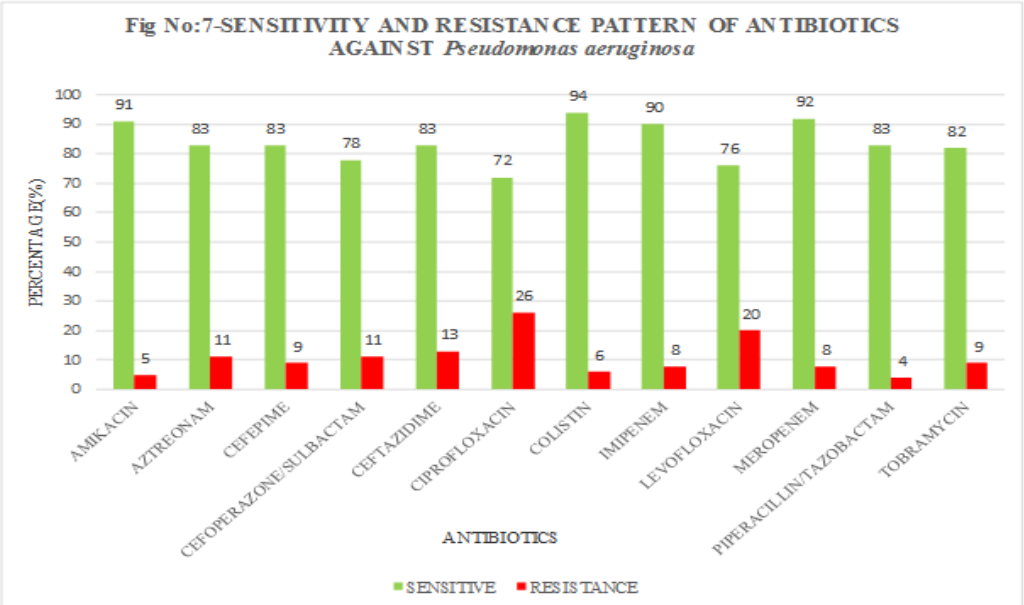
Piperacillin/tazobactam (100% sensitive)

- **2nd line: Cefoperazone/salbactam (100% sensitive)**
Cefoxitin (100% sensitive)
- **Restricted (broad spectrum): Tigecycline (100% sensitive)**

Fig No: 6-Antibiogram of Non-Fermenter Group.

Pseudomonas aeruginosa			Organism
R	M	S	
5	6	91	AMIKACIN
11	7	8	AZTREONAM
9	11	83	CEFEPIME
11	4	78	CEFOPERAZONE/SULBACTAM
13	2	83	CEFTAZIDIME
26		72	CIPROFLOXACIN

6		94	COLISTIN
8	2	90	IMIPENEM
20	4	76	LEVOFLOXACIN
8		92	MEROPENEM
4	13	83	PIPERACILLIN/TAAZOBACTAM
9	2	82	TOBRAMYCIN

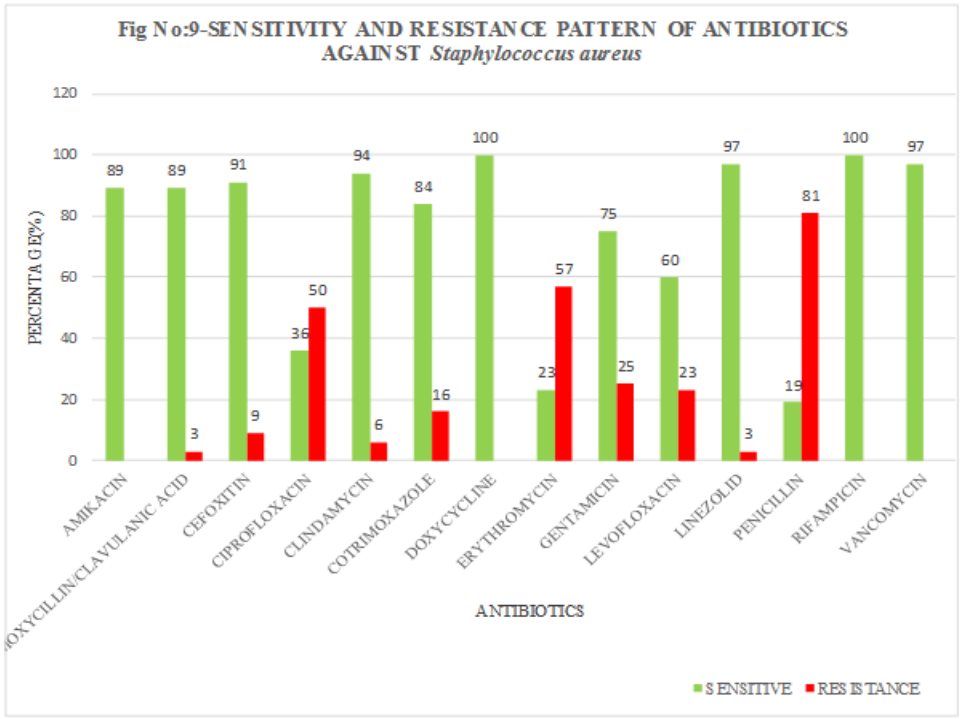


INFERENCE

- *Pseudomonas aeruginosa* is highly sensitive to all of the tested antibiotics with maximum efficacy towards Colistin (94%) and meropenem (92%). It shows 26% resistance towards Ciprofloxacin.
- From the antibiogram of *Pseudomonas aeruginosa*, the recommended empirical therapy is
  - **1st line: Amikacin (91% sensitive)**
  - **2nd line: Meropenem (92% sensitive)**
  - **Restricted (broad spectrum): Colistin (94% sensitive)**

Fig No: 8-Antibiogram of Gram-positive *Staphylococcus* group.

Staphylococcus aureus			**Organism**
R	M	S	
	11	89	AMIKACIN
3	8	89	AMOXYCILLIN/CLAVULANIC ACID
9		91	CEFOXITIN
50	14	36	CIPROFLOXACIN
6		94	CLINDAMYCIN
16		84	COTRIMOXAZOLE
		100	DOXYCYCLINE
57	20	23	ERYTHROMYCIN
25		75	GENTAMICIN
23	17	60	LEVOFLOXACIN
3		97	LINEZOLID
81		19	PENICILLIN
		100	RIFAMPICIN
	3	97	VANCOMYCIN



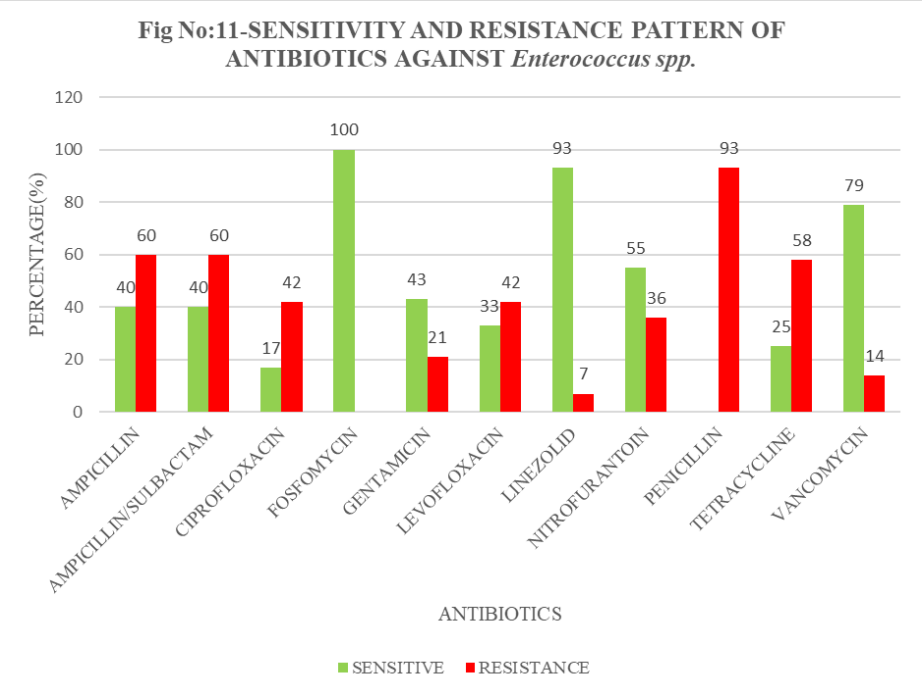
INFERENCE

- It shows high resistance towards Penicillin (81%) and Erythromycin (57%). The most effective antibiotic against *Staphylococcus species* is Doxycycline and Rifampicin (100%) followed by Vancomycin (97%).
- From the antibiogram of *Staphylococcus species*, the recommended empirical therapy is
  - **1st line : Doxycycline(100% sensitive)**
  - **2nd line : Linezolid (97% sensitive)**
  - **Restricted (broad spectrum) : Rifampicin (100% sensitive)**

Fig No: 10-Antibiogram of Gram-positive *Streptococcus* and *Enterococcus* group.

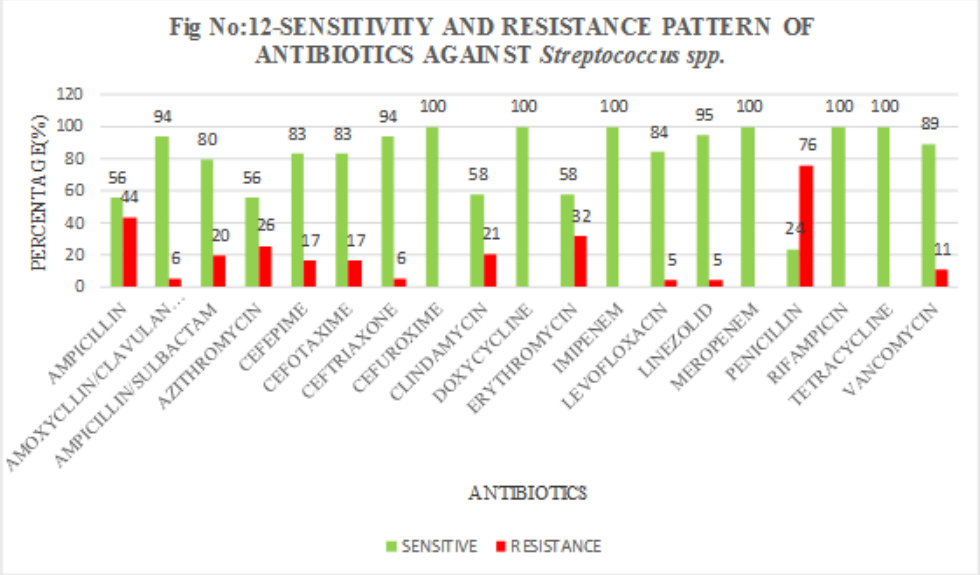
Streptococcus spp.			*Enterococcus spp.*			Organism
R	M	S	R	M	S	
44		56	60		40	AMPICILLIN
6		94				AMOXYCILLIN/CLAVULANIC ACID
20		80	60		40	AMPICILLIN/SULBACTAM
26	16	56				AZITHROMYCIN
17		83				CEFEPIME
17		83				CEFOTAXIME
6		94				CEFTRIAXONE
		100				CEFUROXIME
			42	42	17	CIPROFLOXACIN
21	21	58				CLINDAMYCIN
		100				DOXYCYCLINE
32	11	58				ERYTHROMYCIN
					100	FOSFOMYCIN
			21	36	43	GENTAMICIN
		100				IMIPENEM
5	11	84	42	25	33	LEVOFLOXACIN

5		95	7		93	LINEZOLID
		100				MEROPENEM
			36	9	55	NITROFURANTOIN
76		24	93	7		PENICILLIN
		100				RIFAMPICIN
		100	58	17	25	TETRACYCLINE
11		89	14	7	79	VANCOMYCIN



INFERENCE

- *Enterococcus species* is highly sensitive to Fosfomycin (100%) and linezolid (93%) whereas 93% resistant towards Penicillin and 60% to Ampicillin.
- From the antibiogram of *Enterococcus organism*, the recommended empirical therapy is
  - **1st line : Nitrofurantoin for UTI (55% sensitive)**
  - **2nd line : Linezolid (93% sensitive)**
  - **Restricted (broad spectrum) : Fosfomycin for UTI (**100% sensitive)



INFERENCE

- *Streptococcus species* is resistant towards Penicillin (76%), others show minimal resistance. It is 100% effective towards Cefuroxime, Doxycycline, Imipenem, Meropenem, Rifampicin and Tetracycline.
- From the antibiogram of *Streptococcus species*, it is concluded that the most effective narrow spectrum antibiotic against the bacteria is
- **1st line : Ceftriaxone (94% sensitive)**
- **2nd line : Doxycycline (100% sensitive)**
  Meropenem (100% sensitive)
  Tetracycline (100% sensitive)
- **Restricted (broad spectrum) : Cefuroxime(100% sensitive)**
  Imipenem (100% sensitive)

Rifampicin (100% sensitive

CONCLUSION

This study demonstrated significant variations in the prevalence and antibiotic resistance pattern of bacterial isolates from pus, sputum and urine samples. High resistance was observed against commonly used antibiotics like Ampicillin and Penicillin across all sample type indicating high threat of antimicrobial resistance. These results emphasized that C/S testing should be strictly done to reduce inappropriate antibiotic use. Also, it highlighted the need for drawing awareness among prescribers and to implement stricter regulation on OTC antibiotic sales and the need for implementing strict antibiotic stewardship program and infection control measures through continuous antibiotic susceptibility studies in various clinical samples thereby, guiding effective empirical therapy and to control the spread of resistance.

ACKNOWLEDGMENT

We extend our sincere gratitude and respectful appreciation to Dr. JISHA TU, MBBS, MD Microbiology, SH Medical Centre, Kottayam for her invaluable support, encouragement, and insightful contributions, which played a significant role in the successful completion of this thesis. We are equally grateful to the management, nursing staff, and all other personnel of Tertiary Care Hospital, Kottayam, for their wholehearted assistance throughout the study.

We also wish to acknowledge Dr. AKHILA S ARJUN, Assistant Professor, Department of Pharmacy Practice, KVM College of Pharmacy for her valuable guidance, inestimable encouragement and suggestions rendered for the successful completion of our project work. We humbly owe our gratitude and sincere regards to all our respected faculty of Department of Pharmacy Practice, KVM College of Pharmacy, Cherthala, for their constant inspiration and encouragement to conduct the study.

CONFLICT OF INTEREST

The authors declare no conflict of interest in conducting this study, the design, data collection, analysis, interpretation, reporting its findings or publication of this research.

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