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PREVALENCE OF ANTIBIOTIC RESISTANCE IN A TERTIARY CARE HOSPITAL, AHMEDABAD

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ABSTRACT
Antimicrobial Resistance (AMR) arises when bacteria, viruses, fungi, and parasites develop resistance to antimicrobial agents, rendering treatments ineffective and complicating infection management. This study aims to examine the prevalence of antimicrobial resistance in Ahmedabad. A prospective cohort observational study was conducted over six months in the inpatient ward, involving 1661 patients, following approval from the Institutional Ethics Committee of GCS Medical College, Hospital & Research Centre. Patient Admitted or visiting to the study facility with any disease during the study period were included, while those with isolated fungal cultures were excluded. Statistical analysis involved mean, mode, and percentage. The predominant pathogens observed in the sample include Klebsiella pneumoniae (33.77%), Pseudomonas aeruginosa (23.01%), and Escherichia coli (21.46%). Coagulase-negative Staphylococcus exhibits complete resistance to several antibiotics, including ampicillin, amoxicillin, ceftriaxone, ciprofloxacin, ofloxacin, erythromycin, azithromycin, clarithromycin, tetracycline, doxycycline, and trimethoprim/sulfamethoxazole. This study concluded that Antibiotic resistance is a growing global health crisis driven by the misuse and overuse of antibiotics. The emergence of multidrug-resistant pathogens threatens the effectiveness of current treatments, leading to prolonged illnesses, higher medical costs, and increased mortality.

KEYWORDS: Antibiotics, Antimicrobial resistance, Penicillin, Cephalosporin and Klebsiella pneumonia.

INTRODUCTION
Antimicrobial Resistance (AMR) arises when bacteria, viruses, fungi, and parasites develop resistance to antimicrobial agents, rendering treatments ineffective and complicating infection management. This accelerates disease transmission, increases morbidity and mortality, and diminishes the efficacy of antibiotics and other antimicrobials.[1] While AMR is a natural evolutionary process driven by genetic mutations, its rapid escalation is primarily fueled by the misuse and overuse of antimicrobials in human, animal, and agricultural settings. The 2022 Global Antimicrobial Resistance and Use Surveillance System (GLASS) report highlights alarming resistance trends, with median rates of 42% for third-generation cephalosporin-resistant Escherichia coli and 35% for methicillin-resistant Staphylococcus aureus across 76 countries. Notably, 20% of E. coli-induced urinary tract infections exhibited reduced susceptibility to standard antibiotics, while Klebsiella pneumoniae demonstrated increasing resistance to critical treatments.[2] The growing reliance on last-resort antibiotics, such as carbapenems, is further threatened by rising resistance levels worldwide. Projections by the Organization for Economic Cooperation and Development (OECD) suggest a twofold increase in resistance to last-line antibiotics by 2035 compared to 2005, emphasizing the urgency of strengthening antimicrobial stewardship and surveillance. Concurrently, the World Health Organization (WHO) is closely monitoring the rising prevalence of drug-resistant fungal infections, particularly multidrug-resistant Candida auris, which poses significant treatment challenges, especially for immunocompromised individuals.[3] The aim of this study is to evaluate the prevalence of antibiotic resistance.

METHODOLOGY
Study site: GCS Medical College, Hospital & Research Centre, Ahmedabad, Gujarat, India.
Study design: A prospective observational study

Study duration: 6 months, August 2023 to February 2024
Study population: 1661 inpatients
Study Ethical Approval: This study was approved by the institutional ethics committee of GCS Medical College, Hospital & Research centre.

Inclusion criteria
- Patient data available with complete medical records will be considered.
- Patient Admitted to or visiting the study facility during the study period.

Exclusion criteria
- Isolated fungal cultures will be excluded.

Method of data collection
The study was conducted at GCS Hospital, Ahmedabad, Gujarat, a 750-bed multi-specialty healthcare facility. This hospital-based, prospective observational study took place in the microbiology department over a six-month period. A total of 1661 patients receiving treatment with or without antibiotics, were included. Patient medical records were reviewed to collect comprehensive data, which was systematically documented using a structured patient proforma.

Study procedure
We directly took the data from microbiology lab without any interaction with patient.

Statistical analysis
The data was then systematically transferred to an Excel sheet. Descriptive statistical methods, including mean, mode and percentage calculations, were applied.

RESULTS
Table 1 indicates that Klebsiella pneumoniae was the most frequently identified pathogen.

Table 1: Prevalence of pathogen identified among patients.

Pathogen Identified	Percentage (%)	Number of Cases
Acinetobacter baumanii	4.36	73
Escherichia coli	21.46	359
Enterococcus faecalis	0.48	8
Enterococcus faecium	0.54	9
Enterococcus sp.	3.41	57
Klebsiella pneumoniae	33.77	565
Pseudomonas aeruginosa	23.01	385
Stenotrophomonas maltophilia	0.72	12
Proteus mirabilis	2.09	35
Salmonella typhi	0.36	6
Staphylococcus aureus	8.97	150
Staphylococcus, coagulase-negative	0.12	2
Total	100	1661

Table 2 illustrates the antibiotic resistance patterns of E. coli and Enterococcus faecalis among high number of patients. Table 3 indicates that Enterococcus faecium exhibits significant resistance to a wide range of broad-spectrum antibiotics.

Table 2: Antibiotic resistance and sensitivity among E.Coli and Enterococcus faecalis.

Antibiotics (E. coli)	R (%)	S (%)	I (%)	Antibiotics (Enterococcus faecalis)	R (%)	S (%)	I (%)
Ampicillin	91.62	8.38	0	**Ampicillin**	0	100	0
Amoxicillin	91.62	8.38	0	**Amoxicillin**	0	100	0
Amoxicillin/Clavulanic acid	35.2	64.25	0.56	**Amoxicillin/Clavulanic acid**	0	100	0
Ampicillin/Sulbactam	35.2	64.25	0.56	**Ampicillin/Sulbactam**	0	100	0
Cefotaxime	77.93	22.07	0	**Cefuroxime**	100	0	0
Cefixime	77.81	22.19	0	**Cefotaxime**	100	0	0
Cefepime	47.21	52.51	0.28	**Cefepime**	100	0	0
Piperacillin/Tazobactam	26.33	73.67	0	**Piperacillin/Tazobactam**	0	100	0
Cefoperazone/Sulbactam	26.89	73.11	0	**Cefoperazone/Sulbactam**	100	0	0
Cefepime/Tazobactam	24.44	75.56	0	**Cefepime/Tazobactam**	100	0	0
Imipenem	17.74	81.04	1.22	**Imipenem**	0	100	0
Meropenem	16.98	81.79	1.23	**Meropenem**	0	100	0
Ertapenem	17.85	80.92	1.23	**High level Gentamicin**	14.29	85.71	0
Amikacin	13.97	86.03	0	**Amikacin**	100	0	0
Gentamicin	28.57	71.1	0.32	**Ciprofloxacin**	50	50	0
Netilmicin	13.97	86.03	0	**Ofloxacin**	50	50	0

Tobramycin	28.57	71.1	0.32	**Norfloxacin**	60	40	0
Ciprofloxacin	72.83	27.17	0	**Levofloxacin**	12.5	87.5	0
Ofloxacin	73.18	26.82	0	**Erythromycin**	100	0	0
Norfloxacin	76.86	23.14	0	**Azithromycin**	100	0	0
Levofloxacin	49.72	46.65	3.63	**Tetracycline**	50	50	0
Doxycycline	49.16	50.28	0.56	**Doxycycline**	50	50	0
Tigecycline	0	100	0	**Clindamycin**	100	0	0
Colistin	0	100	0	**Linezolid**	0	100	0
Polymixin B	0	100	0	**Vancomycin**	0	100	0
Fosfomycin	4.83	95.17	0	**Teicoplanin**	0	100	0
Sulfamethoxazole/Trimethoprim	62.85	37.15	0	**Sulfamethoxazole/Trimethoprim**	100	0	0
Nitrofurantoin	20.77	79.23	0	**Nitrofurantoin**	0	100	0

Table 3: Antibiotic resistance and sensitivity among Enterococcus faecium.

Antibiotics (Enterococcus faecium)	R (%)	S (%)	I (%)
Ampicillin	100	0	0
Amoxicillin	100	0	0
Amoxicillin/Clavulanic acid	100	0	0
Ampicillin/Sulbactam	100	0	0
Cefuroxime	100	0	0
Cefotaxime	100	0	0
Cefepime	100	0	0
Cefoperazone/Sulbactam	100	0	0
Cefoxitin	100	0	0
Imipenem	100	0	0
Meropenem	100	0	0
High level Gentamicin	88.89	11.11	0
Amikacin	100	0	0
Ciprofloxacin	100	0	0
Ofloxacin	100	0	0
Levofloxacin	55.56	44.44	0
Erythromycin	100	0	0
Azithromycin	100	0	0
Clarithromycin	100	0	0
Tetracycline	55.56	44.44	0
Doxycycline	55.56	44.44	0
Clindamycin	100	0	0
Linezolid	0	100	0
Vancomycin	11.11	88.89	0
Teicoplanin	11.11	88.89	0
Sulfamethoxazole/Trimethoprim	100	0	0
Nitrofurantoin	83.33	16.67	0

Table 4 highlights the significant resistance patterns of Enterococcus species and Acinetobacter baumannii to various antibiotics. Table 5 highlights the significant resistance of Klebsiella pneumoniae to various penicillins and cephalosporins. Table 6 indicates that Pseudomonas aeruginosa exhibits high resistance to cephalosporins, carbapenems, and fluoroquinolones. Table 7 indicates that Stenotrophomonas maltophilia exhibits significant resistance to β-lactams, cephalosporins, carbapenems, and aminoglycosides. Table 8 indicates that Proteus mirabilis exhibits complete resistance to doxycycline, tigecycline, colistin, and polymyxin B. Table 9 indicates that Salmonella typhi exhibits no resistance to any tested antibiotics. Table 10 indicates that Staphylococcus aureus demonstrates significant resistance to ampicillin, amoxicillin, cloxacillin, and fluoroquinolones, including ciprofloxacin and ofloxacin. Table 11 indicates that coagulase-negative Staphylococcus exhibits complete resistance to several antibiotics.

Table 4: Antibiotic resistance and sensitivity among Enterococcus species and Acinetobacter baumanii.

Antibiotics (Enterococcus sp.)	R (%)	S (%)	I (%)	Antibiotics (Acinetobacter baumanni)	R (%)	S (%)	I (%)
Ampicillin	65.45	34.55	0	**Ampicillin**	100	0	0
Amoxicillin	65.45	34.55	0	**Amoxicillin**	100	0	0

Amoxicillin/Clavulanic acid	61.82	38.18	0	**Ampicillin/Sulbactam**	94.52	1.37	4.11
Ampicillin/Sulbactam	63.64	36.36	0	**Cefuroxime**	100	0	0
Cefuroxime	100	0	0	**Ceftriaxone**	98.63	1.37	0
Cefotaxime	100	0	0	**Cefotaxime**	98.63	1.37	0
Cefepime	100	0	0	**Cefixime**	98.63	1.37	0
Piperacillin/Tazobactam	58.33	41.67	0	**Cefepime**	98.63	1.37	0
Cefoperazone/Sulbactam	98.15	1.85	0	**Piperacillin/Tazobactam**	98.55	1.45	0
Cefoxitin	97.67	2.33	0	**Cefoperazone/Sulbactam**	45.21	15.07	39.73
Imipenem	64.15	35.85	0	**Cefepime/Tazobactam**	98.41	1.59	0
Meropenem	64.15	35.85	0	**Imipenem**	100	0	0
High level Gentamicin	78.43	21.57	0	**Meropenem**	100	0	0
Amikacin	100	0	0	**Ertapenem**	100	0	0
Ciprofloxacin	90.91	9.09	0	**Amikacin**	97.26	2.74	0
Ofloxacin	90.91	9.09	0	**Gentamicin**	96.55	3.45	0
Levofloxacin	49.09	50.91	0	**Netilmicin**	97.26	2.74	0
Erythromycin	98.15	1.85	0	**Tobramycin**	96.55	3.45	0
Azithromycin	98.18	1.82	0	**Ciprofloxacin**	91.78	8.22	0
Clarithromycin	100	0	0	**Ofloxacin**	91.78	8.22	0
Tetracycline	80	20	0	**Levofloxacin**	45.21	43.84	10.96
Doxycycline	80	20	0	**Doxycycline**	73.97	26.03	0
Clindamycin	98.18	1.82	0	**Tigecycline**	0	100	0
Linezolid	0	100	0	**Colistin**	0	100	0
Vancomycin	5.45	94.55	0	**Polymixin B**	0	100	0
Teicoplanin	5.45	94.55	0	**Sulfamethoxazole/Trimethoprim**	97.26	1.37	1.37
Sulfamethoxazole/Trimethoprim	100	0	0				
Nitrofurantoin	63.16	36.84	0				

Table 5: Antibiotic resistance and sensitivity among Klebsiella pneumonia.

Antibiotics	Resistance (%)	Susceptible (%)	Intermediate (%)
Ampicillin	100	0	0
Amoxicillin	100	0	0
Amoxicillin/Clavulanic acid	21.1	78.9	0
Ampicillin/Sulbactam	20.92	79.08	0
Cefuroxime	50.8	49.2	0
Ceftriaxone	44.86	55.14	0
Cefotaxime	44.96	55.04	0
Cefixime	44.78	55.22	0
Cefepime	25.93	74.07	0
Piperacillin/tazobactam	17.46	82.54	0
Cefoperazone/Sulbactam	17.17	82.83	0
Cefepime/Tazobactam	18.71	81.29	0
Imipenem	14.98	85.02	0
Meropenem	14.81	85.19	0
Ertapenem	15.01	84.99	0
Amikacin	14.51	85.49	0
Gentamicin	19.17	80.83	0
Netilmicin	14.51	85.49	0
Tobramycin	19.09	80.91	0
Ciprofloxacin	31.86	68.14	0
Ofloxacin	31.74	68.26	0
Levofloxacin	21.24	78.23	0
Doxycycline	30.44	69.2	0
Tigecycline	0	100	0
Polymyxin B	0	100	0
Sulfamethoxazole/Trimethoprim	34.51	65.49	0

Table 6: Antibiotic resistance and sensitivity among Pseudomonas aeruginosa.

Antibiotics	Resistance (%)	Susceptible (%)	Intermediate (%)
Ceftazidime	28.98	71.02	0
Cefepime	22.34	77.66	0
Piperacillin/tazobactam	17.81	81.37	0.82
Cefoperazone/sulbactam	22.86	77.14	0
Cefepime/tazobactam	21.6	78.4	0
Imipenem	27.79	72.21	0
Meropenem	27.87	72.13	0
Aztreonam	19.11	80.37	0.52
Amikacin	18.7	81.3	0
Gentamicin	20.44	79.56	0
Netilmicin	18.75	81.25	0
Tobramycin	20.38	79.62	0
Ciprofloxacin	25.19	74.81	0
Ofloxacin	25.19	74.81	0
Norfloxacin	25.33	74.67	0
Levofloxacin	22.86	76.62	0.52
Gatifloxacin	22.69	76.78	0.53
Colistin	0	100	0
Polymixin b	0	100	0

Table 7: Antibiotic resistance and sensitivity among Stenotrophomonas maltophilia.

Antibiotics	Resistance (%)	Susceptible (%)	Intermediate (%)
Ampicillin	100	0	0
Amoxicillin	100	0	0
Amoxicillin/Clavulanic acid	100	0	0
Ampicillin/Sulbactam	100	0	0
Cefuroxime	100	0	0
Ceftriaxone	100	0	0
Cefotaxime	100	0	0
Cefixime	100	0	0
Cefepime	8.33	91.67	0
Piperacillin/Tazobactam	90.91	9.09	0
Cefoperazone/Sulbactam	0	100	0
Cefepime/Tazobactam	0	100	0
Imipenem	100	0	0
Meropenem	100	0	0
Ertapenem	100	0	0
Amikacin	100	0	0
Gentamicin	100	0	0
Netilmicin	100	0	0
Tobramycin	100	0	0
Ciprofloxacin	0	100	0
Ofloxacin	0	100	0
Levofloxacin	0	100	0
Doxycycline	33.33	66.67	0
Tigecycline	0	100	0
Colistin	0	100	0
Polymixin B	0	100	0
Sulfamethoxazole/Trimethoprim	0	100	0

Table 8: Antibiotic resistance and sensitivity among proteus mirabilis.

Antibiotics	Resistance (%)	Susceptible (%)	Intermediate (%)
Ampicillin	55.88	44.12	0
Amoxicillin	55.88	44.12	0
Amoxicillin/Clavulanic acid	0	100	0

Ampicillin/Sulbactam	0	100	0
Cefuroxime	44.12	55.88	0
Ceftriaxone	38.24	61.76	0
Cefotaxime	39.39	60.61	0
Cefixime	38.24	61.76	0
Cefepime	35.29	64.71	0
Piperacillin/tazobactam	0	100	0
Cefoperazone/Sulbactam	0	100	0
Cefepime/Tazobactam	0	100	0
Imipenem	0	100	0
Meropenem	0	100	0
Ertapenem	0	100	0
Amikacin	14.71	85.29	0
Gentamicin	33.33	66.67	0
Netilmicin	14.71	85.29	0
Tobramycin	32.26	67.74	0
Ciprofloxacin	20.59	79.41	0
Ofloxacin	20.59	79.41	0
Norfloxacin	28.57	71.43	0
Levofloxacin	14.71	85.29	0
Doxycycline	100	0	0
Tigecycline	100	0	0
Colistin	100	0	0
Polymyxin B	100	0	0
Fosfomycin	15.38	84.62	0
Trimethoprim/ Sulfamethoxazole	55.88	44.12	0
Nitrofurantoin	100	0	0

Table 9: Antibiotic resistance and sensitivity among s. typhi.

Antibiotics	Resistance (%)	Susceptible (%)	Intermediate (%)
Ampicillin	0	100	0
Amoxicillin	0	100	0
Ceftriaxone	0	100	0
Cefotaxime	0	100	0
Ceftazidime	0	100	0
Cefixime	0	100	0
Cefepime	0	100	0
Cefoperazone/sulbactam	0	100	0
Ciprofloxacin	0	100	0
Ofloxacin	0	100	0
Levofloxacin	0	100	0
Nalidixic acid	0	100	0
Azithromycin	0	100	0
Tetracycline	0	100	0
Doxycycline	0	100	0
Trimethoprim/ sulfamethoxazole	0	100	0

Table 10: Antibiotic resistance and sensitivity among staphylococcus aureus.

Antibiotics	Resistance	Susceptible	Intermediate
Ampicillin	98.64	1.36	0
Amoxicillin	98.64	1.36	0
Cloxacillin	57.97	42.03	0
Amoxicillin/clavulanic acid	47.62	52.38	0
Ampicillin/sulbactam	47.62	52.38	0
Cefuroxime	47.62	52.38	0
Ceftriaxone	46.81	53.19	0
Cefotaxime	47.26	52.74	0
Cefepime	47.26	52.74	0

Piperacillin/tazobactam	47.06	52.94	0
Cefoperazone/sulbactam	47.59	52.41	0
Cefoxititn	66.67	33.33	0
Imipenem	51.24	48.76	0
Meropenem	50.83	49.17	0
Amikacin	2.04	97.96	0
Netilmicin	2.13	97.87	0
Ciprofloxacin	90.48	9.52	0
Ofloxacin	90.48	9.52	0
Norfloxacin	100	0	0
Levofloxacin	1.36	98.64	0
Erythromycin	46.26	53.74	0
Azithromycin	46.26	53.74	0
Clarithromycin	45.07	54.93	0
Tetracycline	3.4	96.6	0
Doxycycline	2.72	97.28	0
Clindamycin	41.5	58.5	0
Linezolid	0	100	0
Vancomycin	0	100	0
Teicoplanin	0	100	0
Trimethoprim/Sulfamethoxazole	7.48	92.52	0
Nitrofurantoin	16.67	83.33	0

Table 11: Antibiotic resistance and sensitivity among Staphylococcus, coagulase negative.

Antibiotics	Resistance	Susceptible	Intermittent
Ampicillin	100	0	0
Amoxicillin	100	0	0
Amoxicillin/clavulanic acid	50	50	0
Ampicillin/sulbactam	50	50	0
Cefuroxime	50	50	0
Cefotaxime	50	50	0
Cefepime	50	50	0
Piperacillin/tazobactam	50	50	0
Cefoperazone/sulbactam	50	50	0
Imipenem	50	50	0
Meropenem	50	50	0
Amikacin	0	100	0
Netilmicin	0	100	0
Ciprofloxacin	100	0	0
Ofloxacin	100	0	0
Levofloxacin	0	100	0
Erythromycin	100	0	0
Azithromycin	100	0	0
Clarithromycin	100	0	0
Tetracycline	100	0	0
Doxycycline	100	0	0
Clindamycin	50	50	0
Linezolid	0	100	0
Vancomycin	0	100	0
Teicoplanin	0	100	0
Trimethoprim/ sulfamethoxazole	100	0	0

DISCUSSION

The rapid rise of antibiotic resistance poses a significant challenge for healthcare providers worldwide, limiting effective treatment options. Between 2017 and 2020, antimicrobial resistance (AMR) rates surged for key antibiotics, including ciprofloxacin in Salmonella spp. bloodstream infections, azithromycin in Neisseria gonorrhoeae, and meropenem along with third-generation cephalosporins in Escherichia coli bloodstream infections. A particularly alarming trend is the increasing resistance of Klebsiella pneumoniae to

third-generation cephalosporins, potentially driving greater reliance on carbapenems.[1-4]

A study established a direct link between antibiotic consumption and resistance, underscoring the urgent need for rational prescribing, particularly in developing nations, where approximately half of antibiotics used for prophylaxis and treatment were deemed unnecessary. Before the COVID-19 pandemic, global antimicrobial usage showed a downward trend, with a notable reduction in high-income nations (8.4%) compared to developing regions (1.2%). However, in March 2020, antimicrobial consumption spiked by 11.2% compared to 2019, with substantial increases in both developed (48.2% for antivirals, 6.9% for antibiotics) and developing countries (110.0% for antivirals, 5.9% for antibiotics).[6]

An analysis of 107,053 positive culture isolates conducted by ICMR from January 1 to December 31, 2022, identified E. coli as the most prevalent pathogen, followed by Staphylococcus aureus, Pseudomonas aeruginosa, Acinetobacter baumannii, and K. pneumoniae. A concerning trend from 2017 to 2022 revealed a decline in susceptibility to imipenem, with K. pneumoniae dropping from 59% to 42% and E. coli from 81% to 66%, further highlighting the growing challenge of AMR.[7]

The predominant pathogens observed in the sample include Klebsiella pneumoniae (33.77%), Pseudomonas aeruginosa (23.01%), and Escherichia coli (21.46%). Additionally, other notable bacterial isolates include Staphylococcus aureus (8.97%), Acinetobacter baumannii (4.36%), and Enterococcus species (4.43%). Meanwhile, certain pathogens were detected at lower frequencies, such as Salmonella typhi (0.36%) and coagulase-negative Staphylococcus (0.12%).

E. coli exhibits a high resistance rate to commonly used antibiotics such as ampicillin and amoxicillin (91.62%). In contrast, carbapenems show a comparatively lower resistance rate (17.52%), suggesting their potential efficacy. Aminoglycosides demonstrate moderate resistance levels, whereas antibiotics like tigecycline and colistin exhibit no resistance, making them viable treatment options. For Enterococcus faecalis, cephalosporins (cefuroxime, cefotaxime, cefepime) and macrolides (erythromycin, azithromycin) exhibit complete resistance (100%). Aminoglycosides, such as high level gentamicin, show moderate resistance (14.29%), while fluoroquinolones (ciprofloxacin and ofloxacin) display an equal distribution between susceptibility and resistance (50%). Notably, newer antibiotics such as linezolid, vancomycin, and teicoplanin maintain full susceptibility, highlighting their effectiveness in managing Enterococcus faecalis infections.

Enterococcus species exhibit high resistance to commonly used antibiotics, including ampicillin, amoxicillin, cefuroxime, cefepime, cefotaxime, and ciprofloxacin, with resistance rates ranging from approximately 65% to over 90%. However, these bacteria remain susceptible to linezolid, teicoplanin, and vancomycin, with resistance rates around 5%. Notably, Enterococcus species display complete resistance to amikacin, clarithromycin, and several other antibiotics. Similarly, A. baumannii demonstrates complete resistance to carbapenems (100%) and shows a high level of resistance to cephalosporins such as ceftriaxone (98.63%) and cefotaxime (98.63%). Additionally, a significant proportion of A. baumannii isolates exhibit resistance to aminoglycosides like amikacin (97.26%) and fluoroquinolones such as ciprofloxacin (91.78%). Levofloxacin, and other fluoroquinolone, displays moderate resistance at 45.21%. In contrast, tigecycline, colistin and polymixin B, remain fully effective (100% susceptibility) against this pathogen. Furthermore, resistance patterns for combination antibiotics like cefoperazone/sulbactam (45.21% resistant, 15.07% susceptible) indicate the complex nature of antimicrobial resistance in A. baumannii.

Klebsiella pneumoniae exhibits high resistance to commonly prescribed antibiotics such as ampicillin, amoxicillin, and ceftriaxone, with resistance rates ranging from approximately 45% to over 66%. In contrast, it remains largely susceptible to carbapenems (imipenem, meropenem, ertapenem) and aminoglycosides (amikacin, gentamicin, netilmicin), with resistance rates below 20%. Additionally, Klebsiella pneumoniae shows complete susceptibility to specific agents, including tigecycline, and polymyxin B, reinforcing the crucial role of carbapenems and aminoglycosides in empirical treatment strategies.

Pseudomonas aeruginosa resistance rates for commonly used antibiotics, including ceftazidime, cefepime, imipenem, meropenem, ciprofloxacin, and levofloxacin, range from approximately 20% to 30%. In contrast, the pathogen demonstrates greater susceptibility to aminoglycosides (amikacin, gentamicin, netilmicin) and the monobactam aztreonam, with resistance rates below 20%. Notably, Pseudomonas aeruginosa remains fully susceptible to colistin and polymyxin B, underscoring their critical role in managing multidrug-resistant infections.

Stenotrophomonas maltophilia exhibits significant resistance to β-lactams, cephalosporins, carbapenems, and aminoglycosides, with resistance rates consistently reaching 100%. Despite its resistance to commonly used antibiotics, it remains susceptible to certain agents, including cefepime, piperacillin/tazobactam, and doxycycline, with resistance rates ranging from approximately 8% to 90%. Notably, S. maltophilia demonstrates complete susceptibility to colistin, polymyxin B, and tigecycline.

Proteus mirabilis exhibits complete resistance to doxycycline, tigecycline, colistin, and polymyxin B. In contrast, it demonstrates full susceptibility (100%) to amoxicillin/clavulanic acid and piperacillin/tazobactam. Moderate resistance (55.88%) is observed with ampicillin and amoxicillin. Additionally, cefepime/tazobactam and meropenem display complete efficacy (100%) against Proteus mirabilis, highlighting their potential as effective treatment options.

S. typhi demonstrates full susceptibility (100%) to various antimicrobial agents, including ampicillin, amoxicillin, ceftriaxone, ciprofloxacin, azithromycin, and several others.

Staphylococcus aureus demonstrates significant resistance to ampicillin, amoxicillin, cloxacillin, and fluoroquinolones, including ciprofloxacin and ofloxacin, with resistance rates ranging from approximately 46% to 98%. However, it remains susceptible to several antibiotics, such as netilmicin, amikacin, tetracycline, linezolid, and vancomycin, with susceptibility rates reaching up to 100%.

Coagulase-negative Staphylococcus exhibits complete resistance to several antibiotics, including ampicillin, amoxicillin, ciprofloxacin, ofloxacin, erythromycin, azithromycin, clarithromycin, tetracycline, doxycycline, and trimethoprim/sulfamethoxazole, with resistance rates reaching 100%. However, it remains fully susceptible to specific antibiotics such as amikacin, netilmicin, levofloxacin, linezolid, vancomycin, and teicoplanin, demonstrating a 100% susceptibility rate.

CONCLUSION

Antibiotic resistance is a growing global health crisis driven by the misuse and overuse of antibiotics. The emergence of multidrug-resistant pathogens threatens the effectiveness of current treatments, leading to prolonged illnesses, higher medical costs, and increased mortality. Addressing this issue requires a multifaceted approach, including rational antibiotic use, enhanced infection control, robust surveillance, and the development of novel antimicrobial agents. Public awareness and policy interventions are crucial to curbing resistance and preserving antibiotic efficacy for future generations. Immediate and collaborative action from healthcare professionals, researchers, and policymakers is essential to mitigate the devastating consequences of antibiotic resistance.

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