2022 ANNUAL REPORT

NATIONAL ANTIMICROBIAL RESISTANCE SURVEILLANCE

Unite Against Superbugs: Take Action!

Antimicrobial Resistance Section /Public Health Directorate - MOH

Antimicrobial Resistance Annual Report

Annual Report

Iraq 2022

Antimicrobial Resistance Surveillance System

Ministry of Health

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The growing problem of Antimicrobial Resistance (AMR) has emerged as a major health crisis in almost all countries of the world including Iraq, resulting in an alarming increase in the burden of infections due to multi-resistant bacteria and limiting the choice of antimicrobials for treatment. Hence, it concerns the entire world and requires action at global, national, and regional levels. AMR cannot be eradicated but a multi-sector approach involving a wide range of partners will limit the risk of AMR and minimize its impact on an individual's wellbeing, now and in the future.

Since 2019 Iraq is contributing in the global AMR Surveillance System (GLASS); which was established in 2015 by the World Health Organization (WHO).

AMR surveillance data serves as local evidence and benchmark data for the antimicrobial resistance situation in participating countries. Sharing such surveillance data enables an open dialogue about challenges, differences, and commonalities, and it allows tracking progress and effectiveness of antimicrobial stewardship programs, and policy and action over time, as the surveillance system and antibiotic stewardship initiatives mature.

The ongoing efforts of the Public Health Directorate to monitor AMR surveillance levels and trends, combined with the application of evidence-based insights, lay the groundwork for a comprehensive approach to tackling antimicrobial resistance. By guiding national AMR control policies, the Directorate contributes significantly to safeguarding public health and ensuring the responsible use of antibiotics for current and future generations.

1. Introduction

1.1 Antimicrobial resistance

Antimicrobial resistance (AMR) is defined as antimicrobial resistance to medicines in pathogens such as bacteria, viruses, fungi, and parasites. It's the normal evolutionary process of these microorganisms which is accelerated by the selective pressure exerted by the widespread use and misuse of antimicrobials

Antimicrobial resistance (AMR) has become a major threat to public health worldwide, including in the Middle East. AMR impacts human health due to increased length of stay in hospitals, treatment failures, and significant human suffering and deaths, as well as leading to increased healthcare costs and social costs. Globally, an estimated 700,000 deaths annually are currently attributable to antimicrobial resistance,and this number is expected to increase to 10,000,000 deaths by 2050, with an associated estimated loss tothe global gross domestic product of up to 100 trillion US dollars per year. Without effective antibiotics, the success of major surgeries and cancer chemotherapy would be compromised.

The major drivers behind the occurrence and spread of AMR are the use of antimicrobial agents and the transmission of antimicrobial-resistant microorganisms among humans; animals; and among humans, animals and the environment. While antimicrobial use exerts ecological pressure on bacteria and contributes to the emergence and selection of AMR, poor infection prevention and control practices favor the further spread of these bacteria.

This report focuses on the antibiotic resistance profiles of priority organisms, highlighting the percentage of resistant isolates for each organism and the corresponding antibiotic. The data presented herein underscores the urgency for effective intervention strategies to combat the rising challenge of antibiotic resistance & guiding treatment decisions.

1.2 Surveillance of the antimicrobial resistance:

AMR Surveillance is not only important to better understand the epidemiology of antimicrobial resistance; this data can also be utilized to:

- Estimate the extent and burden of emerging AMR nationally.
- Monitor AMR trends of pathogenic bacteria that cause common infections in humans to take action by policymakers.
- Detect and identify clusters and potential outbreaks of community-associated (CA) and healthcare-acquired infections .
- Develop antibiotic usage guidelines for common infections.
- Assist health professionals with empiric antimicrobial treatment choices, tailored to the antibiotic resistance epidemiology in the patient's geographic region and setting.

1.3 Iraq AMR surveillance system

The national coordinating center (NCC) for antimicrobial resistance in the public health directorate was established in 2017 consisting of a healthcare specialist, pharmacist, and statistician. AMR surveillance system was first established in 2019 then the system was expanded and established nationwide by the Ministry of Health. The Iraq National AMR surveillance system also participates in and provides AMR data to the Global AMR Surveillance System (GLASS), established by the World Health Organization (WHO) in 2015. As of Dec 2022, 73 surveillance sites in the hospitals, were enrolled in the national AMR surveillance system with full equipment and trained personnel using WHONET software for the collection of data on resistant bacteria then send these data monthly to the national coordinating center for aggregation and analysis.

Table (1): Antimicrobial surveillance sites and labs, Iraq, 2022.

No.	Health Directorate	CODE	Number of Surveillance sites
1	Medical City	A	6
2	Al-Karkh	B	11
3	Al-Rusafa	C	13
4	Basra	D	10
5	Nineveh	E	2
6	Kirkuk	F	6
7	Diyala	G	1
8	Maysan	L	1
9	Thi-Qar	M	1
10	Karbala	N	4
11	Al-Najaf	P	3
12	Al-Muthanna	Q	2
13	Wasit	S	1
14	Babil	R	9
15	Sulaymaniyah	V	1
16	Duhok	W	1
17	Diwaniyah	T	1
Total			73

Figure (1): Geographic distribution of antimicrobial sites (public/private), Iraq, 2022.

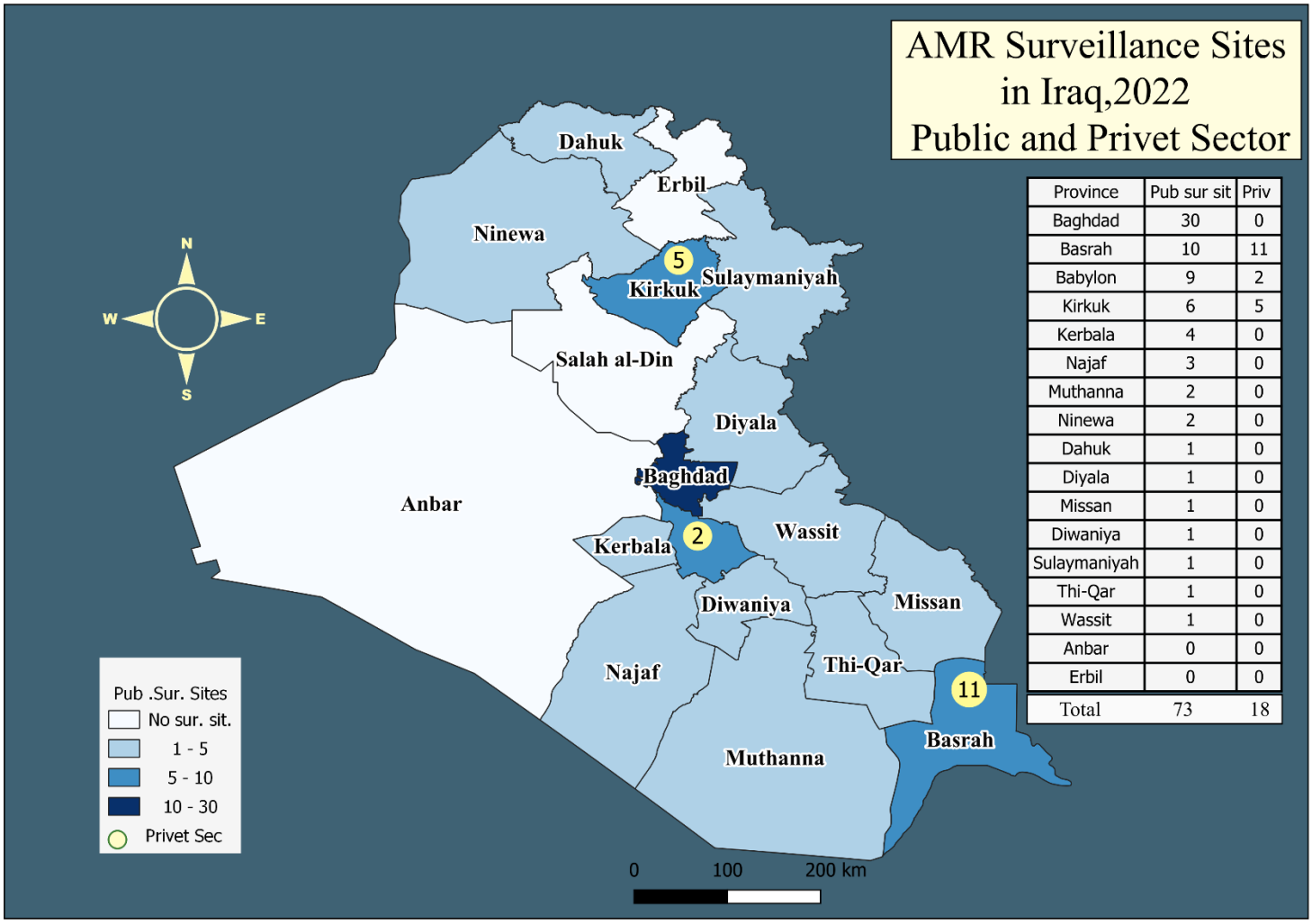
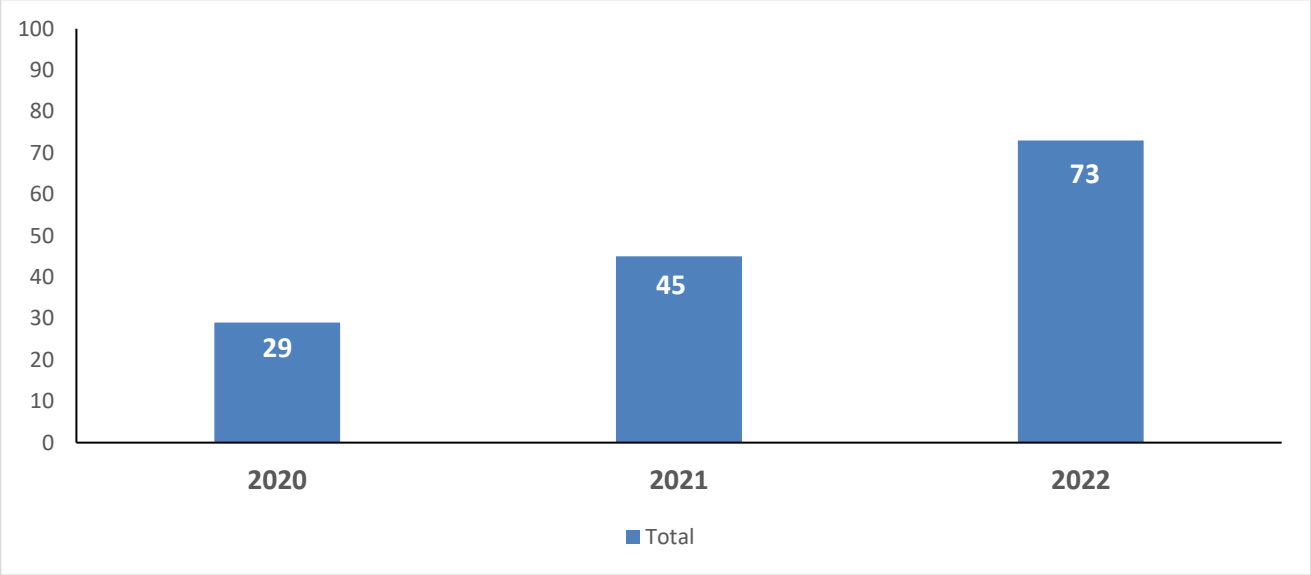


Figure (2): Number of surveillance sites reporting AMR data - by year,Iraq, 2020-2022.



2. Methods

According to Antimicrobial Resistance Surveillance System which is implemented by WHONET (World Health Organization's Antimicrobial Resistance Network) software to monitor and report antimicrobial resistance patterns at the national level. The surveillance method follows a standardized approach to collect, analyze, and report data on antimicrobial resistance from participating laboratories as a surveillance site.

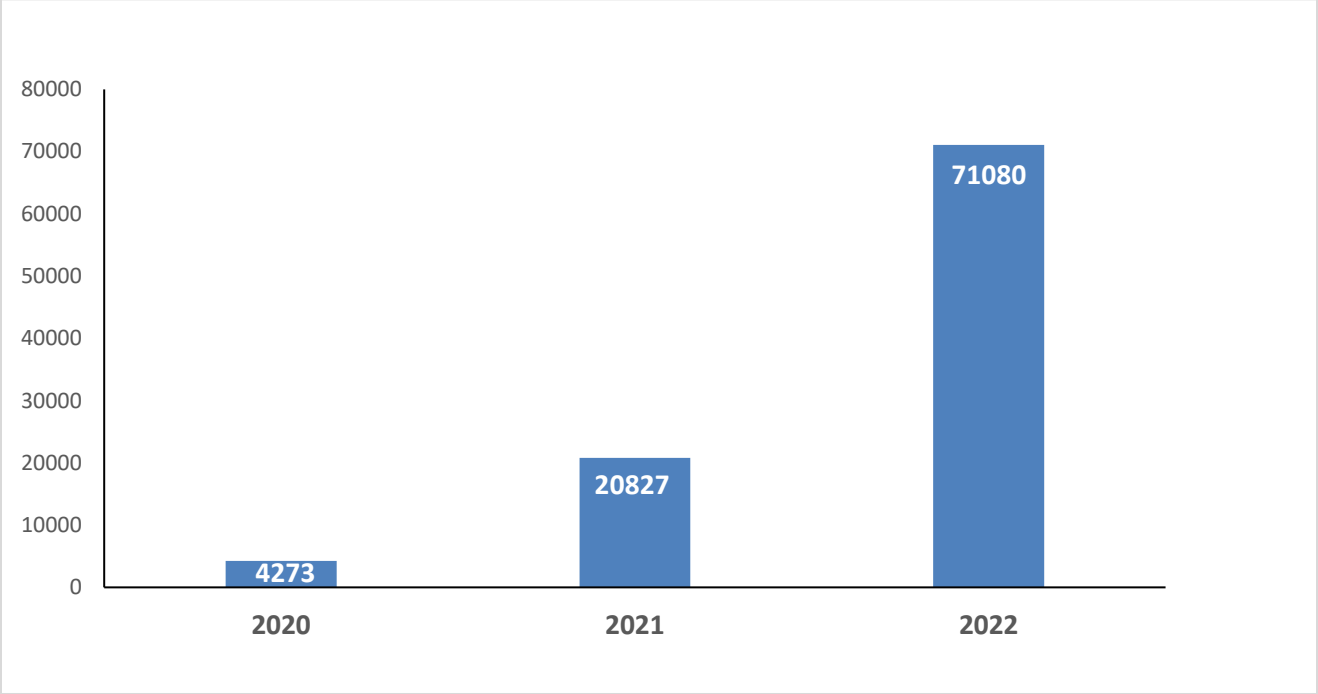
Participating laboratories collect data on antimicrobial susceptibility testing results from clinical isolates obtained from patients. The data includes information on the organism's identification, the antimicrobial agents tested, and the corresponding susceptibility or resistance patterns.

Standardized Testing Methods by use of standardized laboratory methods, including specific techniques for identification of bacterial isolates and standardized antimicrobial susceptibility testing procedures. This ensures consistency and comparability of data across different laboratories.

The collected data is analyzed to determine the prevalence and trends of antimicrobial resistance.Statistical methods are applied to calculate resistance percentages, identify multidrug resistance patterns, and assess changes in resistance over time.

The surveillance promotes the implementation of quality assurance programs in participating laboratories to ensure the accuracy and reliability of the reported data. This involves regular proficiency testing, adherence to quality control protocols, and continuous training and capacity building for laboratory person.

Figure (3): Number of isolates reported by national surveillance sites, by year Iraq, 2020-2022



The National AMR surveillance system collects information on all bacteria by cultural methods and tests for antimicrobial susceptibility as part of the daily patient routine in participating facilities. For analysis and public health reporting, it focuses then on the following (12) bacterial pathogens of public health and clinical importance (enhanced surveillance for AMR priority pathogens) according to the Global Clinical and Laboratory Standards Institute (CLSI):

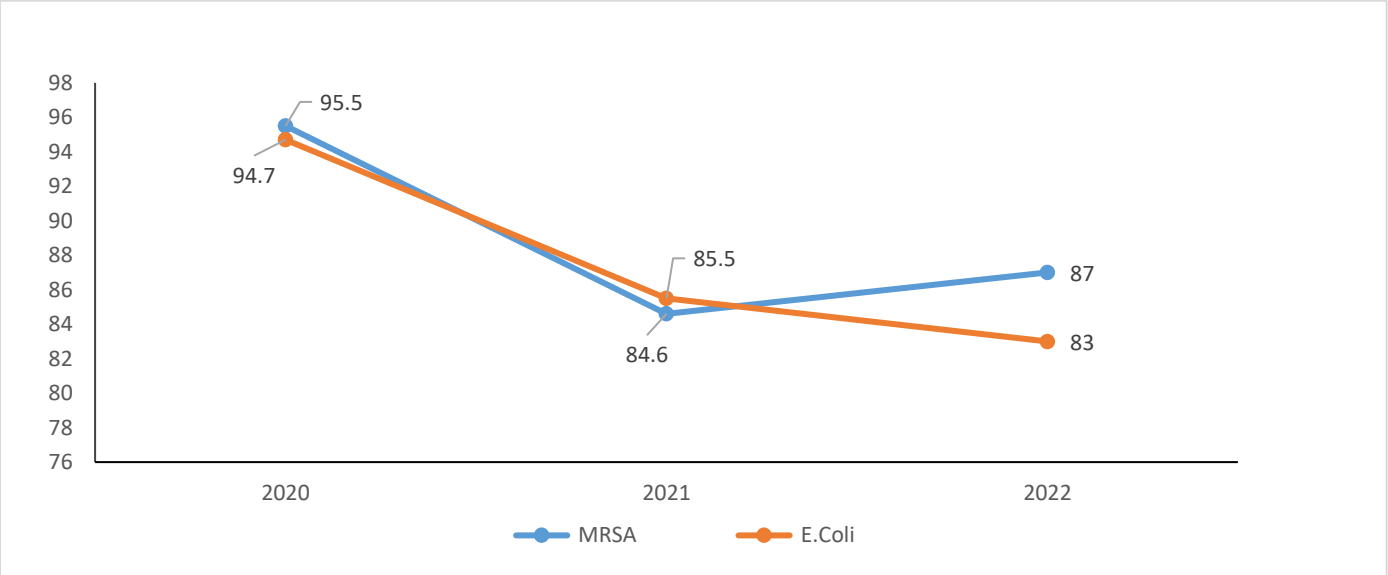
- Escherichia coli (E. coli)
- Klebsiella pneumoniae (K. pneumoniae)
- Salmonella spp.
- Pseudomonas aeruginosa (P. aeruginosa)
- Acinetobacter spp.
- Staphylococcus aureus (S. aureus)
- Streptococcus pneumoniae (S. pneumoniae)
- Enterococcus faecalis (E. faecalis)
- Enterococcus faecium (E. faecium)
- Shigella spp.
- Neisseria gonorrhea
- Hemophilus influenzae

3. Results

3.1 National AMR trend

AMR indicators are the proportion of bloodstream infection due to methicillin-resistant Staphylococcus aureus (MRSA) and Escherichia coli resistant to 3rd-generation cephalosporin (e.g., ESBL- E. coli) among patients seeking care and whose blood sample is taken and test.

Figure (4): AMR annual trend in Iraq.



The AMR (Antimicrobial Resistance) trend for MRSA (Methicillin-resistant Staphylococcus aureus) and E. coli (Escherichia coli) for the years 2020, 2021, and 2022 shows some interesting patterns and fluctuations. AMR is a critical concern in healthcare and public health as it affects the effectiveness of antibiotics in treating infections

MRSA Trend in 2020, the resistance rate was 95.5%, indicating a high level of resistance to methicillin, a commonly used antibiotic. While in 2021, there was a notable decrease in MRSA resistance, with a rate of 84.6%. This suggests a positive trend in reducing resistance to MRSA, however in 2022, the MRSA resistance rate increased slightly to 87%. While it is still lower than the 2020 level, this increase should be monitored closely, as it might indicate a resurgence in MRSA resistance.

E. coli Trend in 2020, the resistance rate was 94.7%, which is also quite high, while in 2021, there was a decrease in resistance to 85.5%, which is a positive sign, however in 2022, E. coli resistance further decreased to 83%, continuing the trend of reduced resistance.

Overall, it appears that there was a decrease in AMR for both MRSA and E. coli between 2020 and 2021, which is a positive development. However, it's essential to note that in 2022, there was a slight increase in resistance for MRSA , which warrants attention.

Possible factors contributing to these trends could include changes in antibiotic prescribing practices, infection control measures in healthcare settings, public awareness campaigns about antibiotic stewardship, and the emergence of new strains of these bacteria with varying resistance patterns.

To effectively address AMR, healthcare systems and policymakers should continue monitoring and analyzing these trends, implementing antimicrobial stewardship programs, promoting responsible antibiotic use, and investing in research and development of new antibiotics and alternative treatments to combat resistant infections.

3.2 Distribution of reported pathogens

For the reporting period 2022 (one year), non-duplicate isolates from 73 surveillance sites are available for analysis, the data provided represents the distribution of various bacterial infections.

Based on the number of cases recorded, the results can be divided into three groups:

Group 1: High case numbers (>1,000 cases):

- Escherichia coli: 6,856 cases
- Staphylococcus aureus ss. aureus: 3,216 cases
- Klebsiella pneumoniae ss. pneumoniae: 1,801 cases
- Pseudomonas aeruginosa: 1,640 cases

Group 2: Moderate case numbers (101-1,000 cases):

- Streptococcus pneumoniae: 200 cases
- Enterococcus faecalis: 293 cases
- Acinetobacter baumannii: 814 cases

Group 3: Low case numbers (≤100 cases):

- Salmonella sp.: 55 cases
- Enterococcus faecium: 52 cases
- Neisseria gonorrhoeae: 26 cases
- Hemophilus influenzae: 10 cases
- Shigella sp.: 10 cases

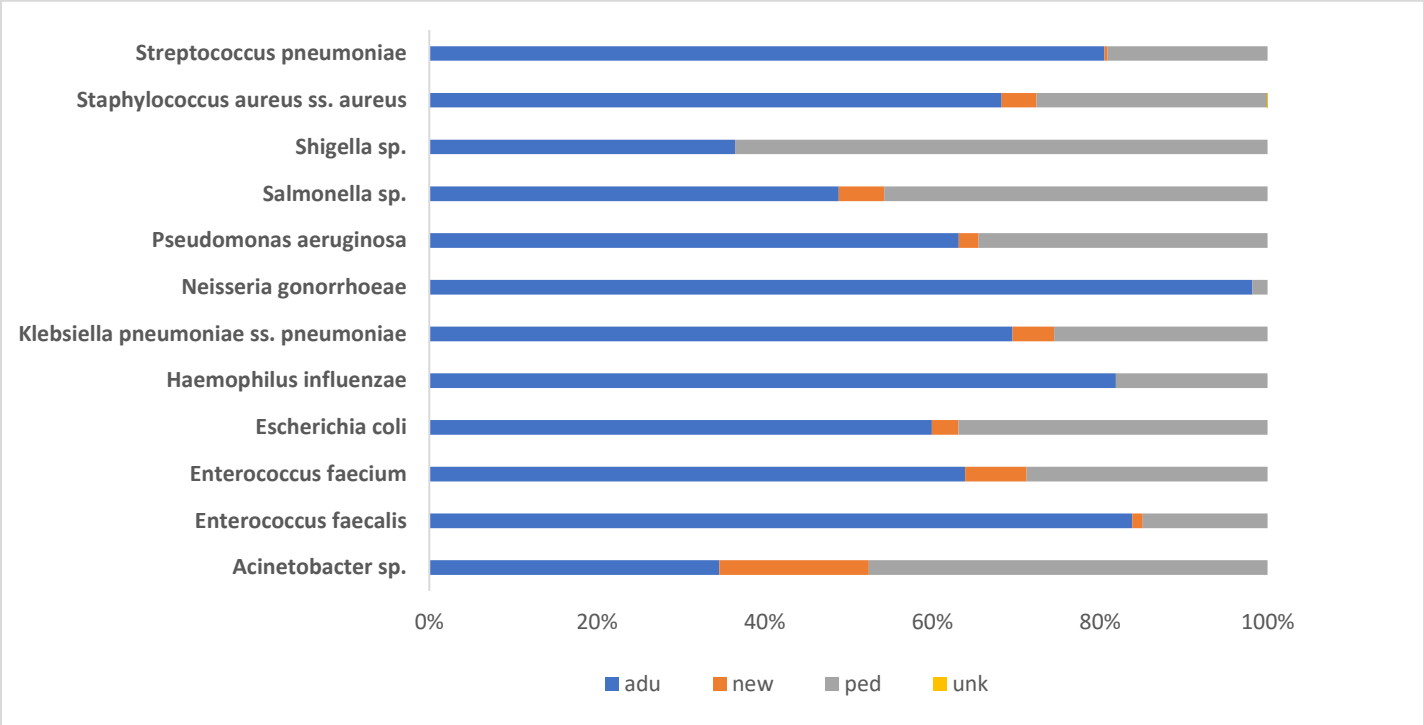
These divisions are based on the magnitude of the recorded cases for each pathogen. This categorization helps provide an overview of the distribution of cases and highlights the pathogens that may require particular attention due to their higher frequency.

The provided data highlights the prevalence and impact of these bacterial infections within the population. This information can aid healthcare professionals in understanding the epidemiology of these organisms and implementing appropriate measures for prevention, control, and treatment.

3.3Distribution according to age.

The provided data represents the distribution of bacterial infections across different age categories, including adults, neonates (newborns), and pediatrics. This information helps us understand the prevalence of these infections within specific age groups

Figure (5): Percentage of reported patients/isolates according to age group Iraq ,2022



Shigella sp. exhibits higher prevalence in the pediatric population, followed by adults, with no reported cases in neonates. Hemophilus influenzae infections are more commonly observed in adults compared to pediatrics, with no reported cases in neonates. Salmonella sp. infections are more prevalent in adults and pediatrics, while neonates have a lower incidence.

Enterococcus faecium infections are more frequently seen in adults, followed by pediatrics and neonates. Neisseria gonorrhoeae infections show a higher incidence in adults, with minimal cases reported in pediatrics and no cases in neonates.

Streptococcus pneumoniae infections are predominantly observed in adults, followed by pediatrics and neonates. Enterococcus faecalis infections are more commonly reported in adults and pediatrics, with fewer cases in neonates.

Acinetobacter sp. exhibits a higher prevalence in pediatrics, followed by adults, with a moderate incidence in neonates. Pseudomonas aeruginosa infections are predominantly observed in adults and pediatrics, with a lower incidence in neonates. Klebsiella pneumoniae ss. pneumoniae infections are more prevalent in adults and pediatrics, while neonates have a lower incidence. Staphylococcus aureus ss. aureus infections are predominantly seen in adults and pediatrics, with a lower incidence in neonates.

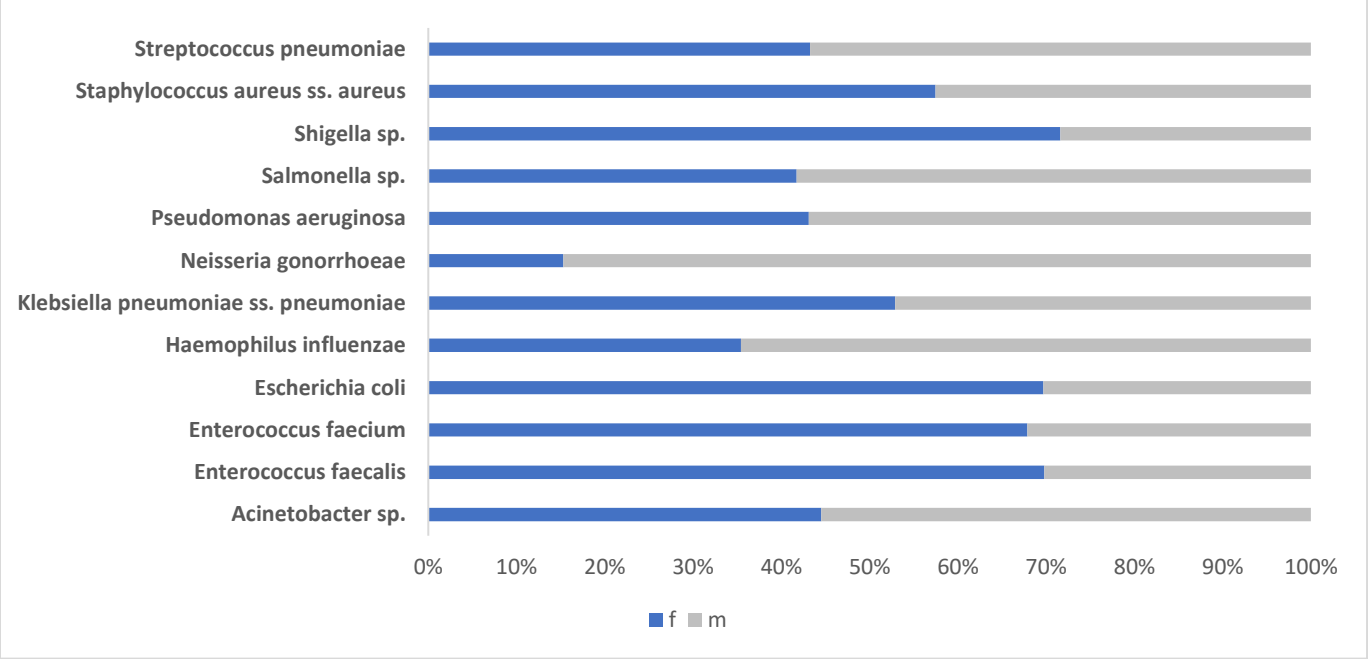
Escherichia coli infections show a higher prevalence in adults, followed by pediatrics and neonates.

Understanding the distribution of bacterial infections across different age groups helps healthcare professionals in developing targeted prevention strategies, implement appropriate treatment approaches, and all allocate sources effectively to address the specific needs of each age category

3.4 Distribution according to Gender.

The provided data represents the count of bacterial infections categorized by gender. It offers insights into the distribution of various bacterial organisms among male and female patients as shown in the figure (6)

Figure (6): Percentage of reported patients/isolates according to gender Iraq ,2022



Escherichia coli shows a higher count among female patients with 54,298 cases, while 23,635 cases are reported in males. Staphylococcus aureus ss. aureus demonstrates a relatively balanced distribution, with 15,405 cases in females and 11,395 cases in males. Similarly, Klebsiella pneumoniae ss. pneumoniae shows a comparable distribution, with 11,530 cases in females and 10,261 cases in males.

Pseudomonas aeruginosa exhibits a higher prevalence among males with 8,785 cases, while 6,660 cases are reported in females. Acinetobacter sp. infections are slightly more prevalent in females with 3,415 cases, compared to 4,257 cases in males.

Streptococcus pneumoniae shows a higher count in females with 783 cases, whereas 1,027 cases are reported in males. Enterococcus faecalis infections are more common in females with 1,520 cases, whereas males account for 658 cases.

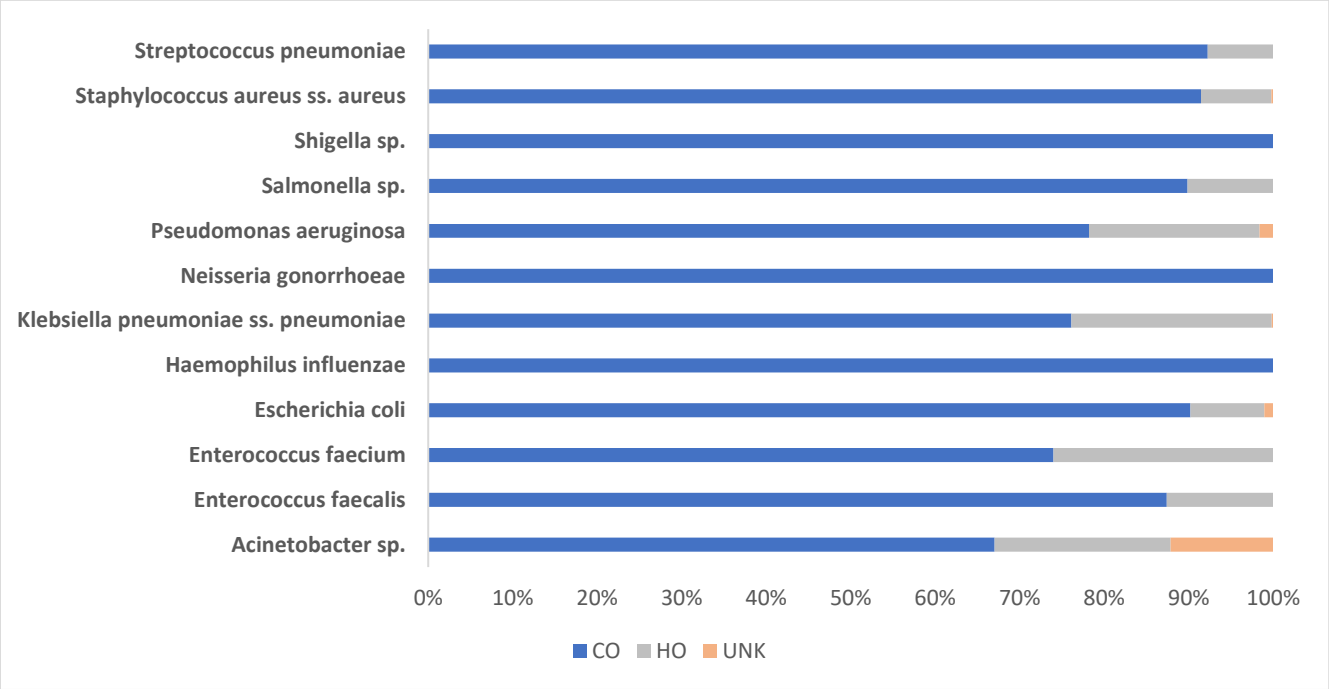
Among less prevalent bacterial infections, Salmonella sp. has 177 cases in females and 247 cases in males. Neisseria gonorrhoeae is reported in 41 females and 227 males. Enterococcus faecium demonstrates a higher count in females with 222 cases, compared to 105 cases in males. Haemophilus influenzae and Shigella sp. also show slightly higher counts in females.

The gender-specific distribution of these bacterial infections provides valuable information for epidemiological analysis and tailored healthcare interventions. Understanding the gender disparities in infection rates can help healthcare professionals develop targeted prevention strategies and optimize treatment approaches based on patient demographics

3.5 Distribution according the infection source.

The provided data presents the sum of the number of cases for various bacterial organisms in the community and hospital settings. The distribution of cases across these settings provides insights into the prevalence and distribution of these organisms in different healthcare settings.

Figure (7): Percentage of reported patients/isolates according to Infection source type Iraq, 2022



Among the bacterial organisms included, Hemophilus influenzae, Shigella sp. and Neisseria gonorrhoeae show high prevalence in community.

Escherichia coli, Staphylococcus aureus ss. Aureus Streptococcus pneumoniae, Salmonella sp and Enterococcus faecalis with more cases in the community rather than in the hospital.

Klebsiella pneumoniae ss. pneumoniae is also notable, with 16,742 cases in the community and 5,207 cases in the hospital.

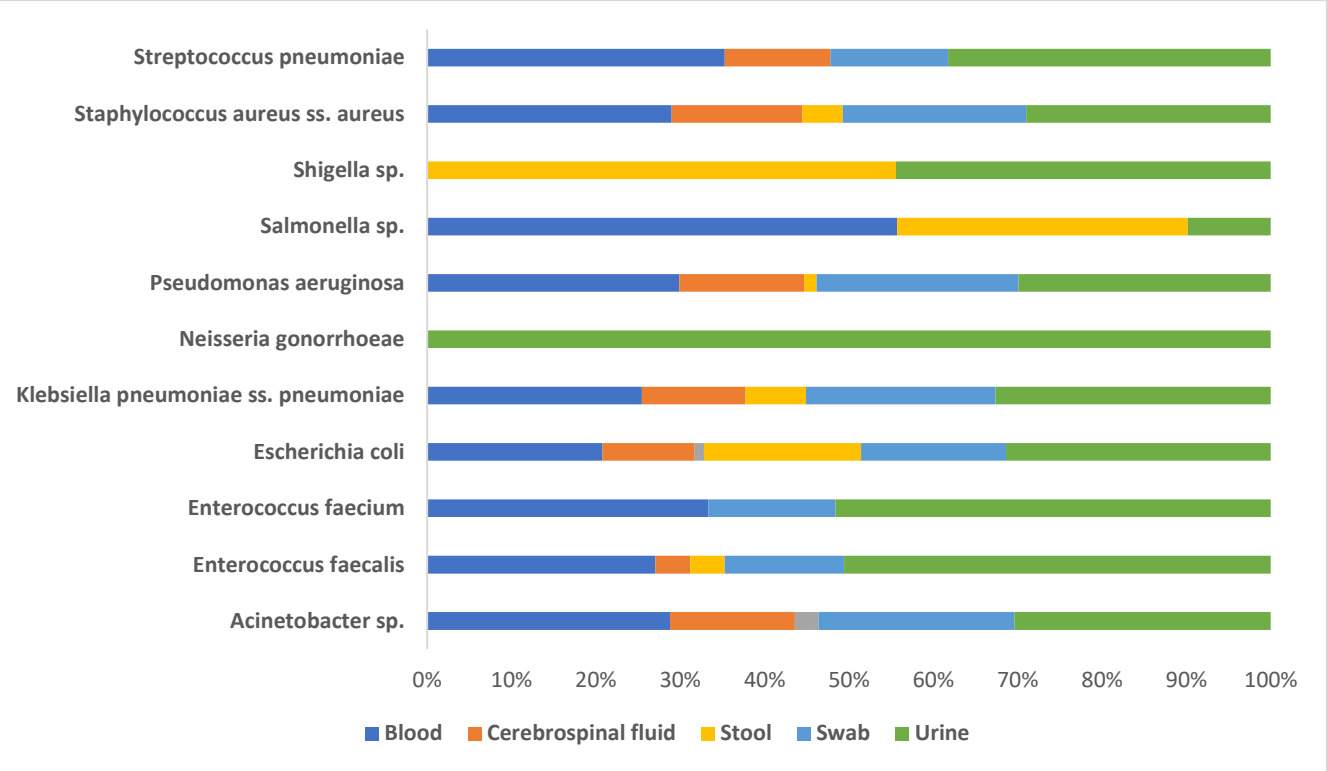
Other organisms such as Acinetobacter sp., Pseudomonas aeruginosa, Klebsiella pneumoniae, Enterococcus faecium exhibits a lower but still significant number of cases in the community and more than other in the hospital.

This distribution reflects the different dynamics and risks associated with community-acquired infections compared to those acquired in healthcare facilities

3.6 Organisms frequencies and specimen categories

The provided data presents the count of cases for various bacterial organisms across different specimen categories, including blood, cerebrospinal fluid, respiratory samples, stool, swabs, and urine. This information allows us to understand the distribution and prevalence of these organisms in different clinical specimens

Figure (8): Percentage of reported patients/isolates according to Specimen type Iraq, 2022



The data provides valuable insights into the distribution of these bacterial organisms across different specimen types. It helps healthcare professionals understand the range of infections associated with these organisms and guides appropriate diagnostic and treatment approaches based on the specimen source.

3.7 Multi-Drug Resistance

The European Centre for Disease Prevention and Control (ECDC) proposed definitions for common bacterial pathogens resistant to multiple antimicrobials.

- **MDR (Multi-Drug Resistance):** defined as acquired non-susceptibility to at least one agent in three or more antimicrobial categories.
- **XDR (eXtensive Drug Resistance)**: defined as non-susceptibility to at least one agent in all but two or fewer antimicrobial categories (i.e., bacterial isolates remain susceptible to only one or two categories).
- **PDR (Pan Drug Resistance)**: defined as non-susceptibility to all agents in all antimicrobial categories.

MDR/XDR/PDR results are summarized in the below table:

Table (2): Percentage of multidrug resistance (MDR), (XDR), (PDR) in Iraq, 2022

Organism	Number of isolates	MDR	XDR	PDR
Acinetobacter sp.	1,642	70%	67%	32%
Klebsiella pneumoniae	1,851	60%	46%	18%
Pseudomonas aeruginosa	1,656	44%	41%	14%
Escherichia coli	6,910	54%	35%	5%
Enterococcus faecium	53	32%	28%	8%
Staphylococcus aureus	3,254	43%	21%	5%
Enterococcus faecalis	294	16%	8%	2%

The resistance profiles of various organisms highlight the concerning prevalence of multidrug-resistant (MDR) strains in healthcare settings. Among the organisms analyzed, Acinetobacter sp. showed the highest proportion of MDR isolates, with 70% exhibiting resistance to multiple classes of antibiotics. Klebsiella pneumoniae followed closely behind with 60% of isolates being MDR.

Pseudomonas aeruginosa and Escherichia coli demonstrated substantial rates of MDR as well, with 44% and 54% of isolates, respectively, showing resistance to multiple antibiotics. Enterococcus faecium exhibited a lower but still significant rate of MDR at 32%, while Staphylococcus aureus and Enterococcus faecalis showed rates of 43% and 16% respectively.

Moreover, the presence of extensively drug-resistant (XDR) strains is also alarming. Among the organisms studied, Acinetobacter sp. and Klebsiella pneumoniae had the highest XDR rates at 67% and 46% respectively, indicating resistance to even more classes of antibiotics. Pseudomonas aeruginosa and Escherichia coli also exhibited notable XDR rates of 41% and 35% respectively.

Additionally, some organisms displayed a concerning prevalence of pan-drug-resistant (PDR) strains, which are resistant to almost all available antibiotics. Acinetobacter sp. had the highest PDR rate at 32%, followed by Klebsiella pneumoniae at 18%, and Pseudomonas aeruginosa at 14%.

3.8 AMR priority pathogen

Table (3): AMR Priority Pathogens – Percentage resistant isolates (%R), Iraq, 2022

Priority	Organism	Antibiotic results	% Resistant isolates
Critical	Escherichia coli	Cefotaxime-resistant	75%
	Escherichia coli	Ceftriaxone-resistant	74%
	Acinetobacter spp.	Carbapenem-resistant	(68%)
	Pseudomonas aeruginosa	Carbapenem-resistant	44%
	Escherichia coli	Meropenem-resistant	13%
High	Staphylococcus aureus	Methicillin-resistant (MRSA)	(65%)
	Neisseria gonorrhoeae	Third generation cephalosporin-resistant	(53%)
	Salmonella spp.	Fluoroquinolone-resistant (Ciprofloxacin)	(50%)
	Enterococcus faecium	Vancomycin-resistant	(49%)
	Neisseria gonorrhoeae	Fluoroquinolone-resistant	(27%)
	Staphylococcus aureus	Vancomycin-resistant	(14%)
	Staphylococcus aureus	Vancomycin-intermediate	(3%)
	Helicobacter pylori	Clarithromycin-resistant	-
	Campylobacter spp.	Fluoroquinolone-resistant	-
Medium	Haemophilus influenzae	Ampicillin-resistant	(80%)
	Streptococcus pneumoniae	Penicillin non-susceptible	(55%)
	Shigella spp.	Fluoroquinolone-resistant	-

This table includes 12 families of bacteria that pose the greatest threat to human health. The list has been divided into three key priorities based on the urgency and needs for new antibiotics

1- Critical Priority Organisms:

Escherichia coli: E. coli displayed substantial resistance rates to key antibiotics. Cefotaxime and ceftriaxone resistance were observed in 75% and 74% of isolates, respectively. However, a comparatively lower resistance rate of 13% was found against meropenem. This highlights the importance of judicious antibiotic use and the exploration of alternative treatment strategies**.**

Acinetobacter spp.: Among the tested isolates, 68% exhibited resistance to carbapenems. This alarming level of resistance necessitates immediate attention and the implementation of stringent infection control measures.

Pseudomonas aeruginosa: Approximately 44% of isolates demonstrated resistance to carbapenems. This emphasizes the need for alternative treatment options to address infections caused by this organism effectively.

2- High Priority Organisms:

Staphylococcus aureus: Methicillin-resistant Staphylococcus aureus (MRSA) was prevalent, with 65% of isolates displaying resistance. Additionally, 14% of isolates exhibited resistance to vancomycin, and 3% showed intermediate resistance to vancomycin. These findings highlight the challenge of combating multidrug-resistant S. aureus infections.

Neisseria gonorrhoeae: Resistance rates were observed for both third-generation cephalosporins (53%) and fluoroquinolones (27%), indicating the urgent need for alternative treatment approaches and the development of new antimicrobials.

Salmonella spp.: Half of the tested isolates (50%) displayed resistance to fluoroquinolones, specifically ciprofloxacin. This highlights the importance of monitoring and surveillance to guide effective treatment strategies.

Enterococcus faecium: Nearly half (49%) of the tested isolates were resistant to vancomycin. This emphasizes the need for vigilant monitoring and infection control practices to prevent the spread of vancomycin-resistant enterococci.

3- Medium Priority Organisms:

Streptococcus pneumoniae: Approximately 55% of isolates were classified as penicillin non-susceptible. This emphasizes the importance of appropriate antimicrobial therapy for treating pneumococcal infections.

Haemophilus influenzae: The majority (80%) of H. influenzae isolates demonstrated resistance to ampicillin. This highlights the need for alternative treatment options and the prudent use of antibiotics.

The high resistance rates among the priority pathogens listed in Table (3) have significant consequences for patient outcomes, healthcare costs, and the effectiveness of treatment and infection control measures. Antibiotic resistance poses a serious threat to human health

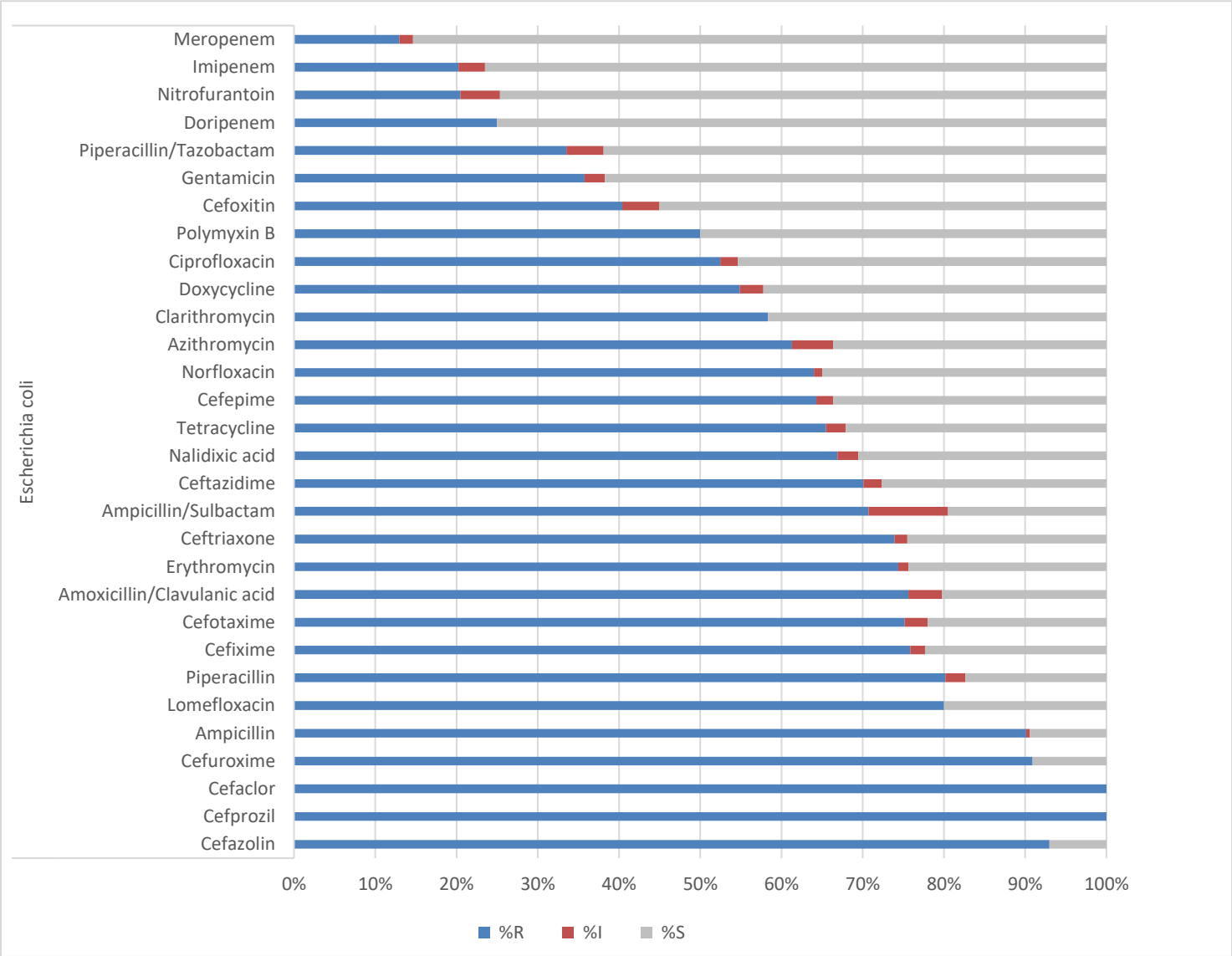
The resistance rates observed among the priority pathogens in Iraq indicate the urgency for action. To mitigate the consequences of high resistance, it is crucial to promote prudent antibiotic use, invest in infection prevention and control measures, and prioritize the development of new antimicrobial agents. Additionally, robust surveillance systems are needed to monitor resistance patterns, guide treatment decisions, and identify emerging resistant strains. Collaboration between healthcare providers, researchers, policymakers, and the community is vital to address this national health threat effectively.

3.9. Resistance Profile for reporting pathogen

3.8.1 Escherichia coli

E. coli is a Gram-negative bacterium commonly found in the intestines of humans and animals. While most strains are harmless, certain pathogenic strains can cause infections in different parts of the body.

Figure (9): Percentages of Resistant, Intermediate, and Susceptible isolates for Escherichia coli among isolates from all sources, Iraq, 2022



The results of susceptibility testing for Escherichia coli (E. coli) against various antibiotics reveal important patterns of resistance and susceptibility.

Among the tested antibiotics, meropenem showed the lowest resistance rate (13%), followed by imipenem (20%) and doripenem (25%), all of which belong to the carbapenem class. Nitrofurantoin, commonly used for urinary tract infections, displayed a low resistance rate (20%), suggesting its potential effectiveness in a significant percentage of cases.

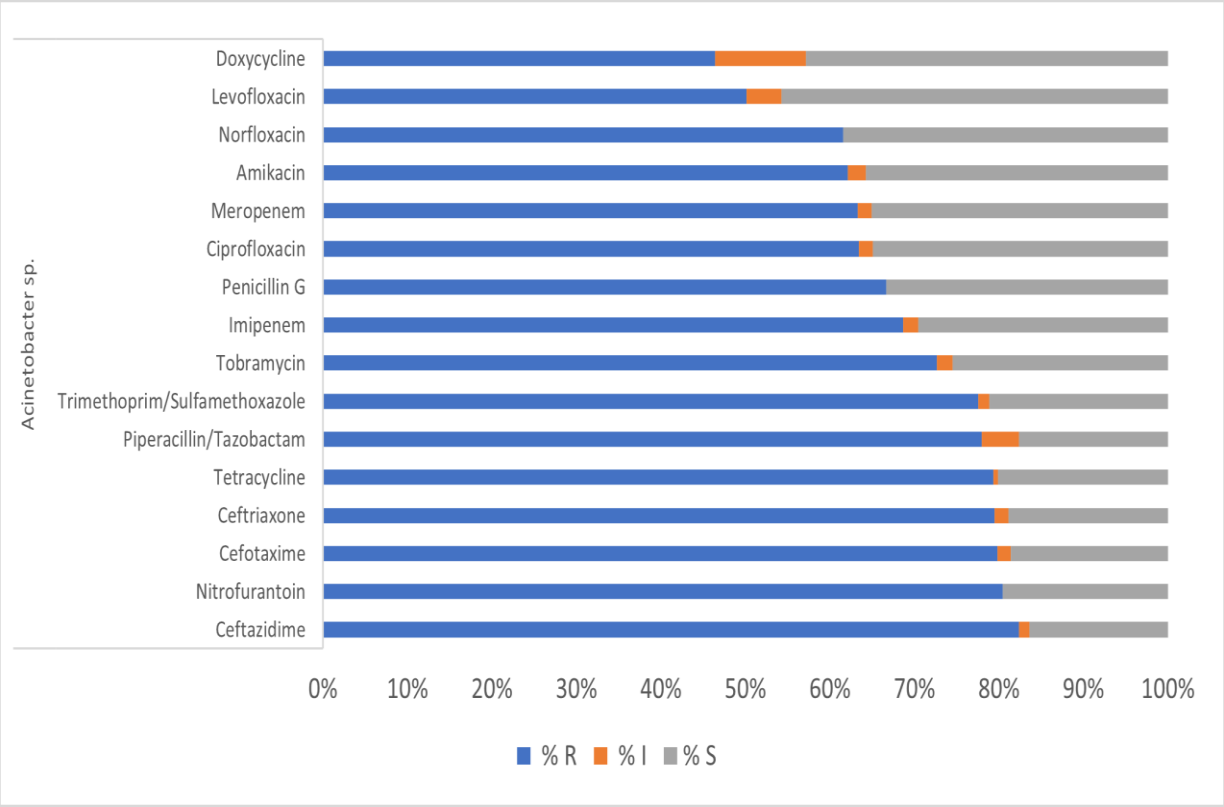
Piperacillin/tazobactam, a beta-lactam/beta-lactamase inhibitor combination, exhibited a moderate resistance rate (33%) compared to other antibiotics. Fluoroquinolones like ciprofloxacin and norfloxacin showed relatively high resistance rates (52% and 64% respectively), while lomefloxacin had a lower resistance rate (80% susceptibility).

The aminoglycoside antibiotic gentamicin demonstrated a moderate resistance rate (36%). Penicillin-related antibiotics such as ampicillin, amoxicillin/clavulanic acid, and ampicillin/sulbactam showed high resistance rates (ranging from 71% to 89%). Tetracycline-related antibiotics like tetracycline and doxycycline displayed relatively high resistance rates (ranging from 55% to 65%).

3.9.2 Acinetobacter spp.

Acinetobacter spp. is a group of Gram-negative bacteria that can cause a variety of infections, particularly in healthcare settings and it is known for its ability to develop resistance to multiple antibiotics, including both commonly used and last-line treatment options

Figure (10): Percentages resistant, intermediate, and susceptible isolates for Acinetobacter spp. among isolates from all sources, Iraq, 2022



The resistance profile of Acinetobacter spp. reveals concerning levels of antibiotic resistance, highlighting the challenges in treating infections caused by this bacterium. The data shows that Acinetobacter spp. has a high overall resistance rate to various antibiotics.

Among the antibiotics tested, doxycycline exhibited a resistance rate of 43%, indicating that this commonly used antibiotic may not be effective against a significant proportion of Acinetobacter spp. infections. Similarly, levofloxacin, norfloxacin, amikacin, and meropenem demonstrated resistance rates ranging from 50% to 63%, limiting their utility in treating Acinetobacter spp. infections.

Ciprofloxacin and penicillin G both exhibited a resistance rate of 63%, indicating a significant challenge in using these antibiotics to target Acinetobacter spp. infections. Imipenem, an important carbapenem antibiotic, showed a resistance rate of 68%, which is alarming considering that carbapenems are often considered last-resort treatment options

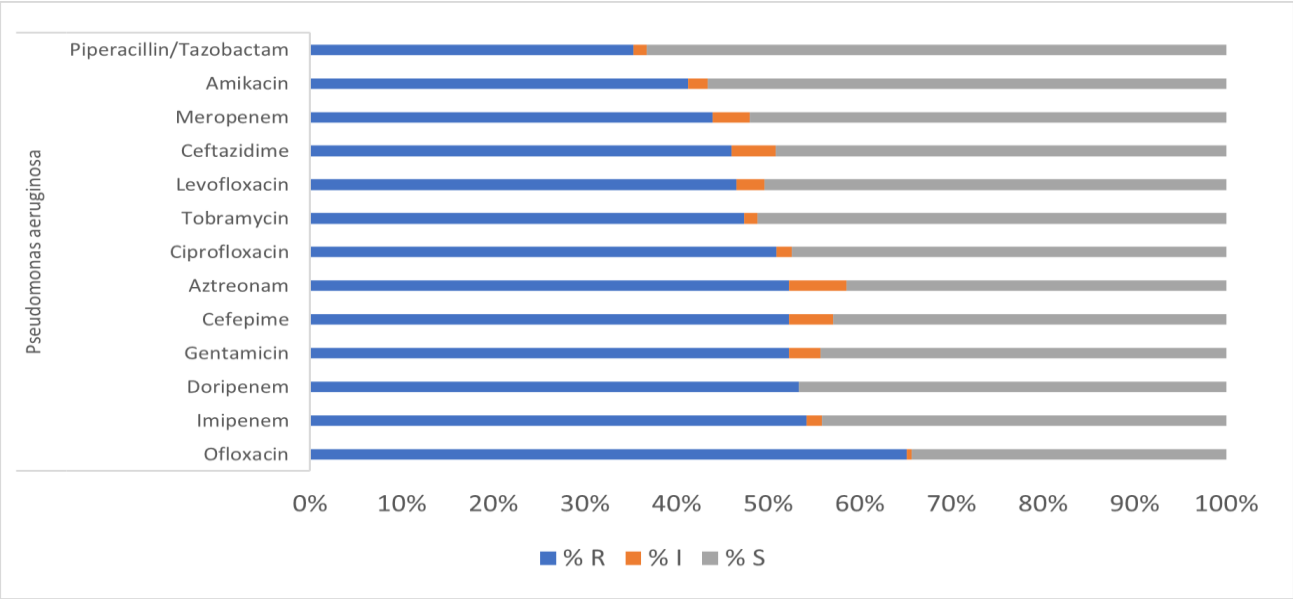
The resistance rates for other antibiotics, such as tobramycin, trimethoprim/sulfamethoxazole, piperacillin/tazobactam, tetracycline, ceftriaxone, cefotaxime, nitrofurantoin, and ceftazidime, ranged from 77% to 82%. These results highlight the limited effectiveness of these antibiotics against Acinetobacter spp. infections, emphasizing the need for alternative treatment options.

The high levels of resistance observed in this resistance profile underscore the importance of implementing appropriate infection control measures, such as strict adherence to hand hygiene and the prudent use of antibiotics, to prevent the spread and emergence of resistant strains of Acinetobacter spp.

3.9.3 Pseudomonas aeruginosa

Pseudomonas aeruginosa is a Gram-negative bacterium that is known for its ability to cause a wide range of infections, can cause a range of infections, including respiratory tract infections (such as pneumonia), urinary tract infections, skin and soft tissue infections, bloodstream infections, and infections in surgical sites. It is a leading cause of healthcare-associated infections, particularly in patients with prolonged hospital stays or those requiring invasive procedure

Figure (11): Percentages of Resistant, intermediate, and Susceptible isolates for Pseudomonas aeruginosa among isolates from all sources, Iraq, 2022



The resistance profile of Pseudomonas aeruginosa ,reveals important insights into the susceptibility of this bacterium to various antibiotics. Pseudomonas aeruginosa is known for its ability to develop resistance, posing significant challenges in the management of infections caused by this pathogen.

Among the antibiotics tested, piperacillin/tazobactam showed a resistance rate of 35%, suggesting moderate efficacy against Pseudomonas aeruginosa. Amikacin exhibited a resistance rate of 41%, indicating a relatively higher level of resistance than the previous.

Meropenem and ceftazidime displayed resistance rates of 44% and 46% respectively, highlighting the presence of resistance mechanisms against these antibiotics. Levofloxacin and tobramycin showed similar resistance rates of 46% and 47% respectively, indicating limited effectiveness against Pseudomonas aeruginosa.

Ciprofloxacin and aztreonam exhibited resistance rates of 51% and 52% respectively, emphasizing the need for caution when using these antibiotics for treating Pseudomonas aeruginosa infections. Cefepime and gentamicin displayed comparable resistance rates of 52%, indicating a significant level of resistance.

It is noteworthy that doripenem and imipenem exhibited resistance rates of 53% and 54% respectively, suggesting limited efficacy of carbapenems against Pseudomonas aeruginosa.

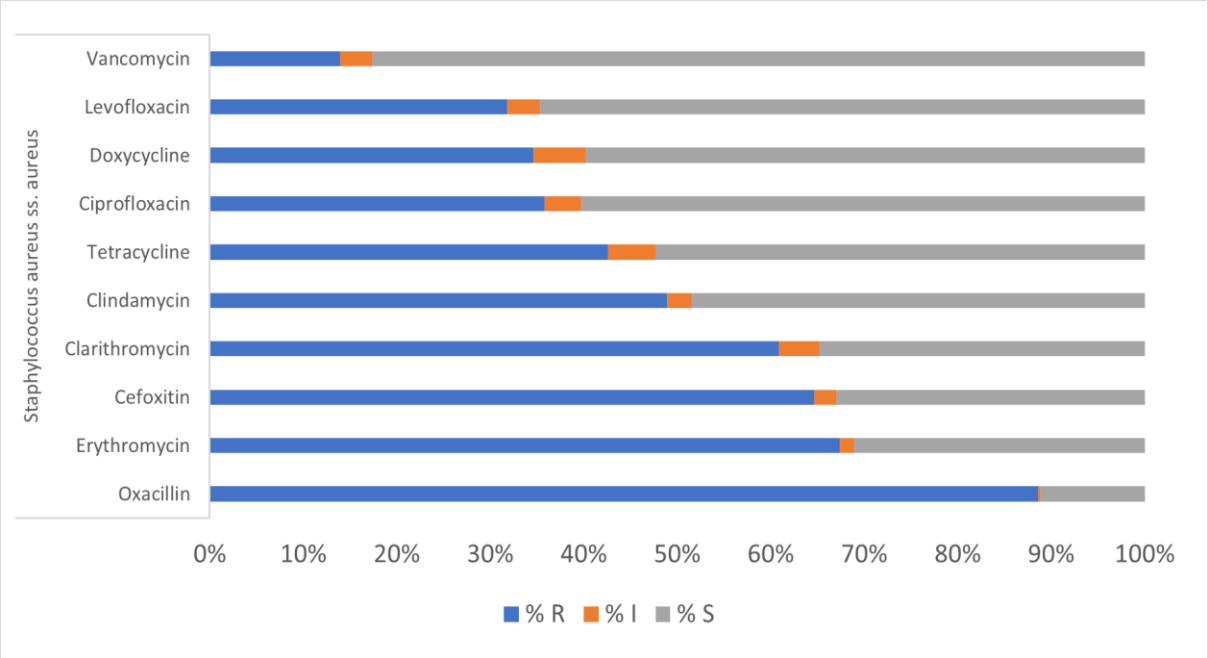
Ofloxacin, a fluoroquinolone antibiotic, showed a resistance rate of 65%, indicating a higher level of resistance and limiting its usefulness in treating Pseudomonas aeruginosa infections.

These resistance patterns emphasize the importance of conducting antimicrobial susceptibility testing toguide appropriate antibiotic selection. In cases of severe infections, combination therapy or alternative agents may be necessary.

3.9.4 Staphylococcus aureus

Staphylococcus aureus is a Gram-positive bacterium that is commonly found on the skin and mucous membranes of humans. While it is a part of the normal flora, it can also cause a wide range of infections, ranging from mild skin infections to severe systemic infections

Figure (12) Percentages of Resistant, Intermediate, and Susceptible isolates for Staphylococcus aureus among isolates from all sources, Iraq, 2022



In the tested antibiotics, vancomycin showed a relatively low resistance rate of 14%, indicating its efficacy in treating Staphylococcus aureus infections. Levofloxacin exhibited a resistance rate of 32%, suggesting a moderate level of effectiveness.

Doxycycline and ciprofloxacin displayed resistance rates of 35% and 36% respectively, indicating a notable level of resistance. Tetracycline showed a resistance rate of 43%, suggesting limited efficacy against Staphylococcus aureus strains.

Clindamycin and clarithromycin exhibited higher resistance rates of 49% and 61% respectively, emphasizing the need for alternative treatment options when dealing with Staphylococcus aureus infections.

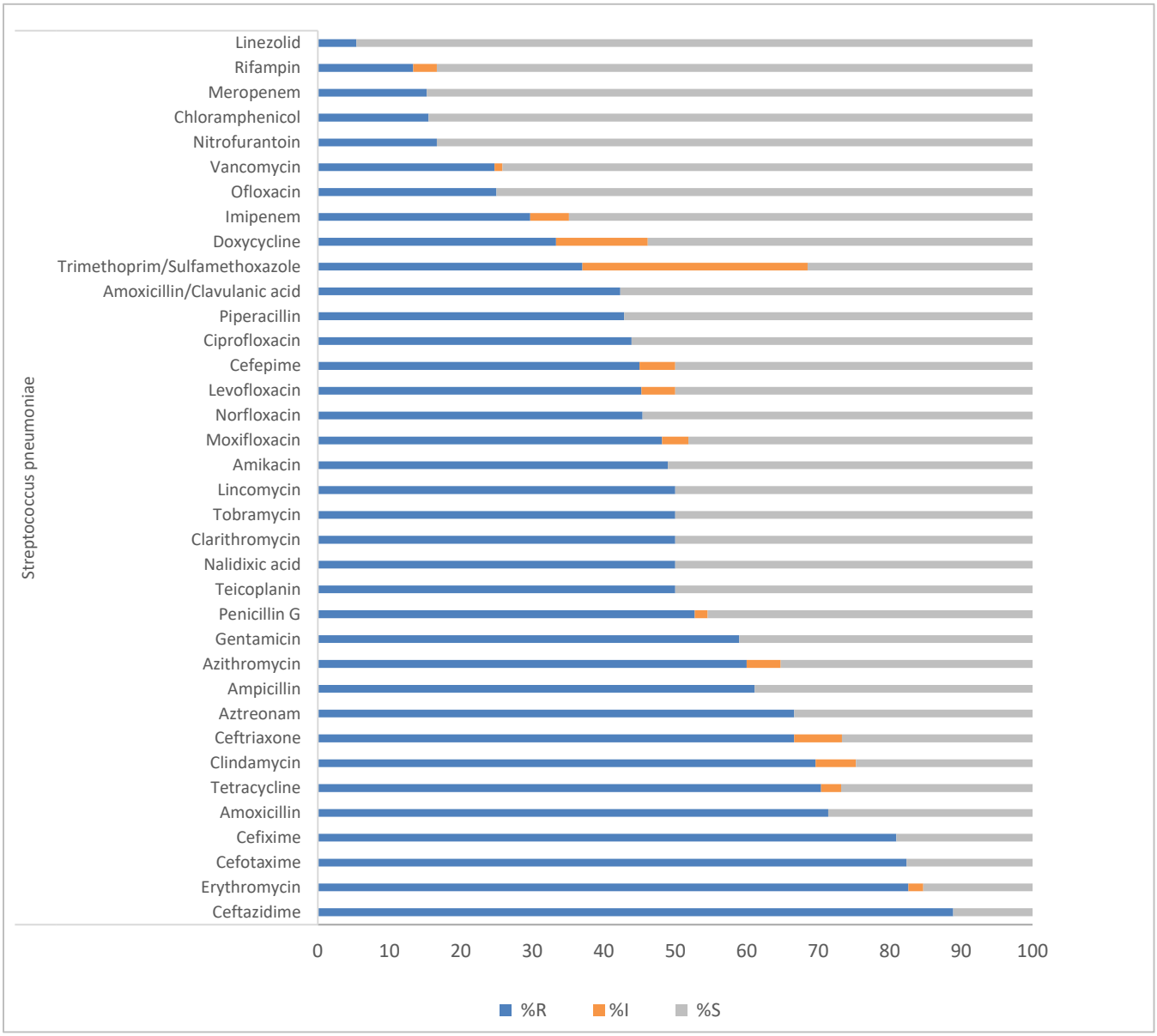
Cefoxitin and erythromycin displayed resistance rates of 65% and 67% respectively, indicating a significant level of resistance. This highlights the challenges in using these antibiotics for the treatment of Staphylococcus aureus infections.

On the other hand, oxacillin showed a high resistance rate of 89%, indicating limited effectiveness against Staphylococcus aureus strains.

3.9.5 Streptococcus pneumoniae

Streptococcus pneumoniae, often referred to as pneumococcus, is a Gram-positive bacterium that commonly colonizes the upper respiratory tract of humans. While it is a commensal bacterium in healthy individuals, it can also cause a range of infections, including pneumonia, meningitis, sinusitis, and otitis media

Figure (13): Percentages of Resistant, Intermediate, and Susceptible isolates for Streptococcus pneumoniae among isolates from all sources, Iraq, 2022



The data show the resistance profile of Streptococcus pneumoniae, reveals important insights into the susceptibility of this bacterium to various antibiotics. Understanding the resistance patterns is crucial for guidingappropriate treatment strategies against pneumococcal infections.

Among the antibiotics tested, linezolid demonstrated a low resistance rate of 5%, indicating its efficacy in treating Streptococcus pneumoniae infections. Rifampicin, another antibiotic commonly used against respiratory pathogens, displayed a resistance rate of 13%, suggesting other effectiveness treatment.

Meropenem and chloramphenicol both exhibited resistance rates of 15% and 16% respectively, indicating a relatively good response to these antibiotics.

However, it is important to note that continued monitoringis necessary to detect any emerging resistance trends. Nitrofurantoin, typically used for urinary tract infections, displayed a resistance rate of 17%, suggestingthat it may still be a viable treatment option for pneumococcal infections.

Vancomycin, a potent antibiotic used against Gram-positive bacteria, showed a resistance rate of 25%, indicating a notable level of resistance. Imipenem and doxycycline , both broad-spectrum antibiotics, exhibited resistance rates of 30% and 33% respectively.

Doxycycline, trimethoprim/sulfamethoxazole, cefotaxime, and ciprofloxacin displayed varying degrees of resistance, with resistance rates ranging from 33% to 44%. This suggests a caution should be exercised when considering these antibiotics for the treatment of Streptococcus pneumoniae infections.

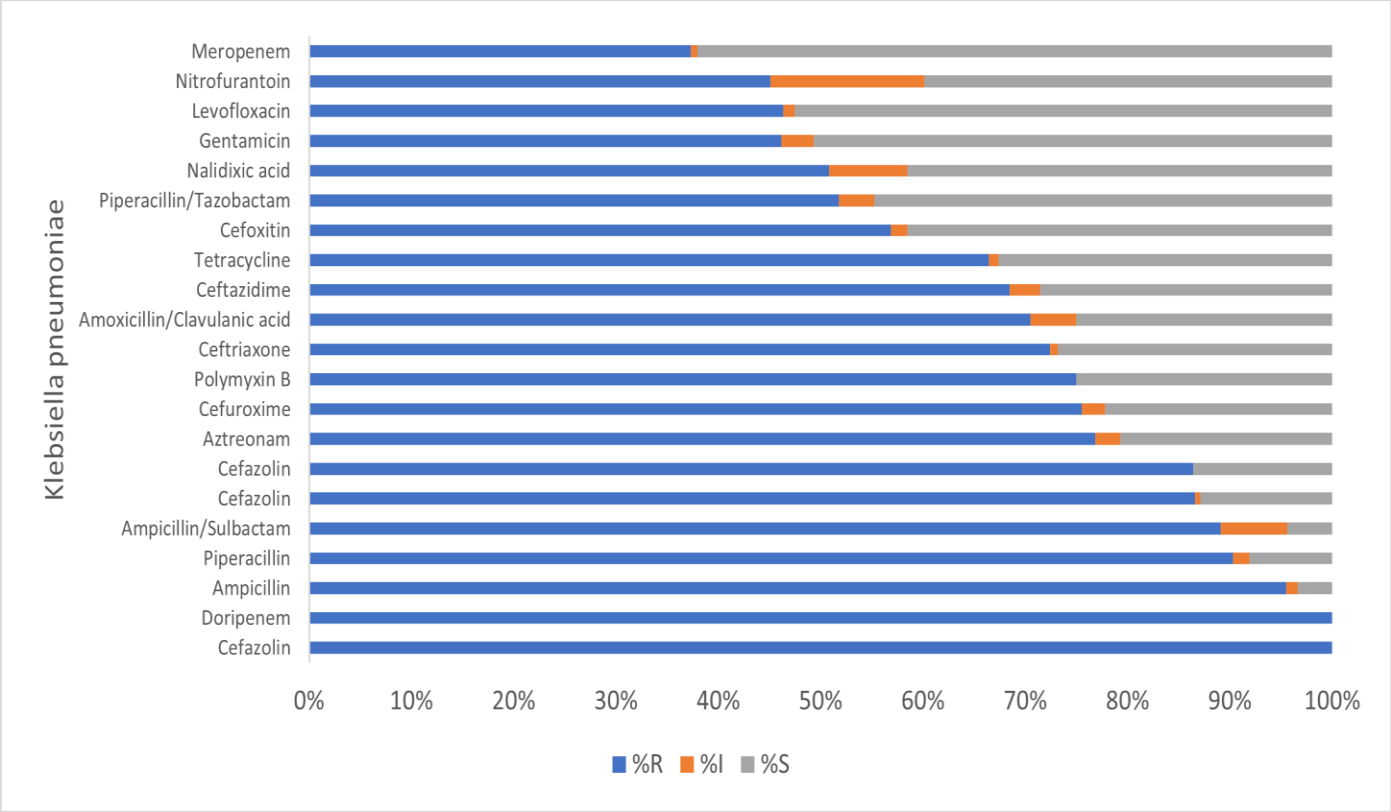
On the other hand, levofloxacin, amikacin, and gentamicin demonstrated resistance rates of 45%, 49%, and 59% respectively, indicating limited efficacy against pneumococcal strains.

Among the tested antibiotics, clindamycin, tetracycline, cefixime, and erythromycin showed higher resistance rates, ranging from 70% to 83%. This highlights the need for alternative treatment options when dealing with pneumococcal infections

3.9.6 Klebsiella pneumoniae

Klebsiella pneumoniae (K. pneumoniae) is a Gram-negative bacterium belonging to the family Enterobacteriaceae. It is a common cause of healthcare-associated infections, particularly in hospital settings. K. pneumoniae can colonize various parts of the body, including the respiratory tract, urinary tract, and bloodstream.

Figure (14): Percentages of Resistant, Intermediate, and Susceptible isolates for Klebsiella pneumoniae among isolates from all sources in Iraq, 2022



Among the tested antibiotics, meropenem showed a relatively resistance rate of 37%. Nitrofurantoin, commonly used for urinary tract infections, displayed more resistance rate of 45%, suggesting caution in its use for K. pneumoniae infections with a wide range of intermediate so can give in higher dose to be more effective.

Levofloxacin and gentamicin, commonly prescribed antibiotics, showed moderate resistance rates of 46%, indicating the need for careful consideration when using these drugs. Piperacillin/tazobactam, abeta-lactam/beta-lactamase inhibitor combination, exhibited a resistance rate of 52%, suggesting limited effectiveness against K. pneumoniae.

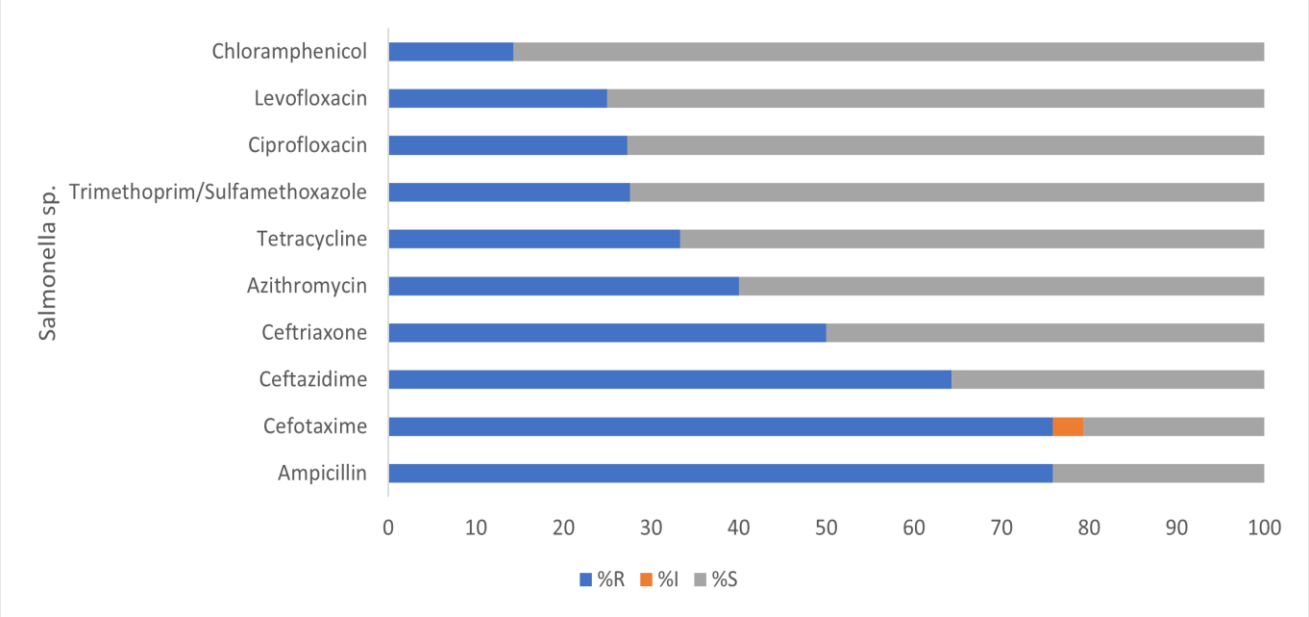
Cefoxitin and tetracycline demonstrated resistance rates of 57% and 66% respectively, indicating reduced efficacy in treating K. pneumoniae infections. Ceftazidime and ceftriaxone showed high resistance rates of 68% and 72% respectively, indicating limited effectiveness against K. pneumoniae.

Ampicillin/sulbactam, piperacillin, and ampicillin exhibited high resistance rates of 89%, 90%, and 94% respectively, suggesting that these antibiotics may not be suitable treatment options for K. pneumoniae infections.

3.9.7 Salmonella spp.

Salmonella is a bacterium that includes several species known to cause foodborne illnesses in humans. These infections can range from mild gastroenteritis to severe systemic diseases. One significant concern in the management of Salmonella infections is the emergence and spread of antibiotic resistance.

Figure (15): Percentages of Resistant, Intermediate, and Susceptible isolates for Salmonella spp. among isolates from all sources in Iraq, 2022



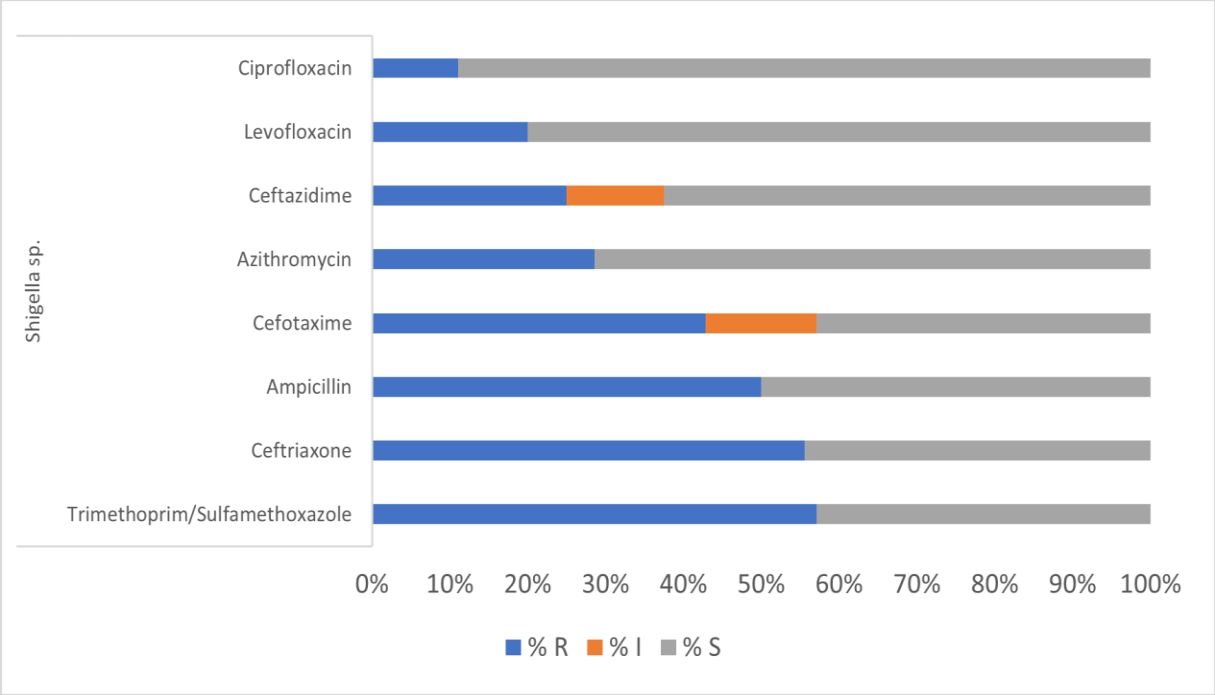
These results indicate the resistance profile Salmonella isolates with prevalence resistance rate 30 %. It is concerning to see high resistance rates for several antibiotics, such as cefotaxime, ampicillin, ceftazidime, and ciprofloxacin, This suggests limited treatment options for infections caused by Salmonella strains with resistance to these antibiotics.

On the other hand, some antibiotics, like chloramphenicol and trimethoprim/sulfamethoxazole, showed relatively lower resistance rates, indicating better susceptibility. However, it is important to note that susceptibility patterns may vary among different Salmonella strains and geographical regions, so these results should be interpreted in the context of the specific study or surveillance data.

3.9.8 Shigella spp.

Shigella spp. is a group of bacteria responsible for causing shigellosis, a highly contagious intestinal infection. Shigellosis is characterized by symptoms such as diarrhea, fever, abdominal pain, and sometimes bloody stools

Figure (16): Percentages of Resistant, Intermediate, and Susceptible isolates for Shigella spp. among isolates from all sources in Iraq, 2022



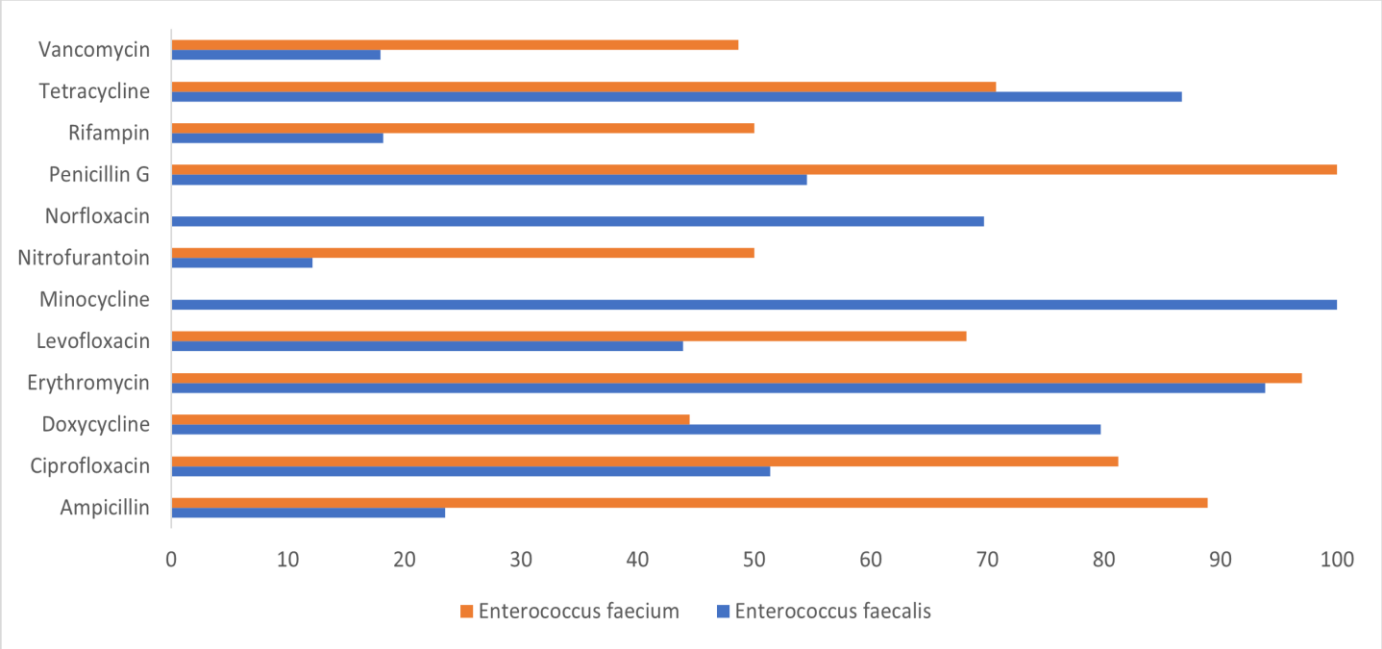
These results indicate the resistance profile Shigella spp. it is concerning to see resistance in several antibiotics commonly used for the treatment of shigellosis. The resistance rates for ceftriaxone, cefotaxime, and trimethoprim/sulfamethoxazole are particularly notable, as they are commonly recommended antibiotics for Shigella infections.

On the other hand, there are still a significant percentage of Shigella spp. isolates that remain susceptible to the tested antibiotics, such as ciprofloxacin, levofloxacin, and ceftazidime. This indicates that these antibiotics can still be effective treatment options for some cases of shigellosis.

3.9.9 Enterococcus faecalis and Enterococcus faecium

Enterococcus faecalis and Enterococcus faecium are two enterococcal species that cause human infections. They differ in their virulence, association with endocarditis and bacteremia, and susceptibility to antibiotics Enterococcus faecalis is more virulent, more likely to cause endocarditis, more susceptible to beta-lactam agents, Enterococcus faecium is less virulent, less likely to cause endocarditis, more resistant to beta-lactam agents.

Figure (17): Percentages of resistant (%R) for Enterococcus faecalis and Enterococcus faecium among isolates from all sources, Iraq, 2022



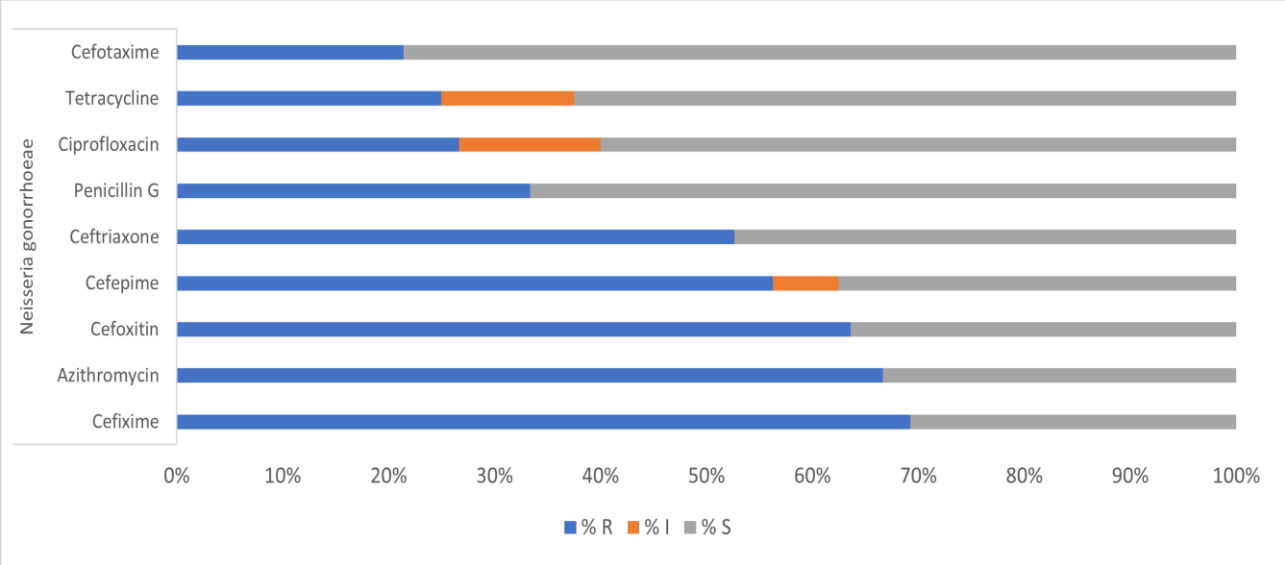
The table shows that Enterococcus faecalis is more resistant than Enterococcus faecium to minocycline, norfloxacin, doxycycline and tetracycline. These antibiotics are either not effective or have limited activity against enterococci faecalis. Minocycline and doxycycline are tetracyclines that inhibit protein synthesis. Norfloxacin, levofloxacin, and ciprofloxacin are fluoroquinolones that inhibit DNA replication.

Enterococcus faecium is more resistant than Enterococcus faecalis to vancomycin, nitrofurantoin, rifampin, levofloxacin, ciprofloxacin, and ampicillin. Vancomycin is a glycopeptide that inhibits cell wall synthesis. Nitrofurantoin is a nitrofuran that damages DNA. Rifampin is a rifamycin that inhibits RNA synthesis. Levofloxacin and ciprofloxacin are fluoroquinolones that inhibit DNA replication. Ampicillin is a beta-lactam that inhibits cell wall synthesis.

3.9.10 Neisseria gonorrhoeae

Neisseria gonorrhoeae, also known as the gonococcus, is a bacterial pathogen responsible for the sexually transmitted infection gonorrhea. It primarily affects the mucous membranes of the reproductive tract, but can also infect the throat, rectum, and eyes.

Figure (18): Percentages of Resistant, Intermediate, and Susceptible isolates for Neisseria gonorrhoeae among isolates from all sources in Iraq, 2022



The data presented reveals the resistance profile of Neisseria gonorrhoeae against various antibiotics.

These results indicate significant resistance rates for several antibiotics, including ceftriaxone, cefepime, cefoxitin, azithromycin and cefixime. This suggests limited treatment options for infections caused by this bacterium, as a significant proportion of isolates are resistant to these antibiotics.

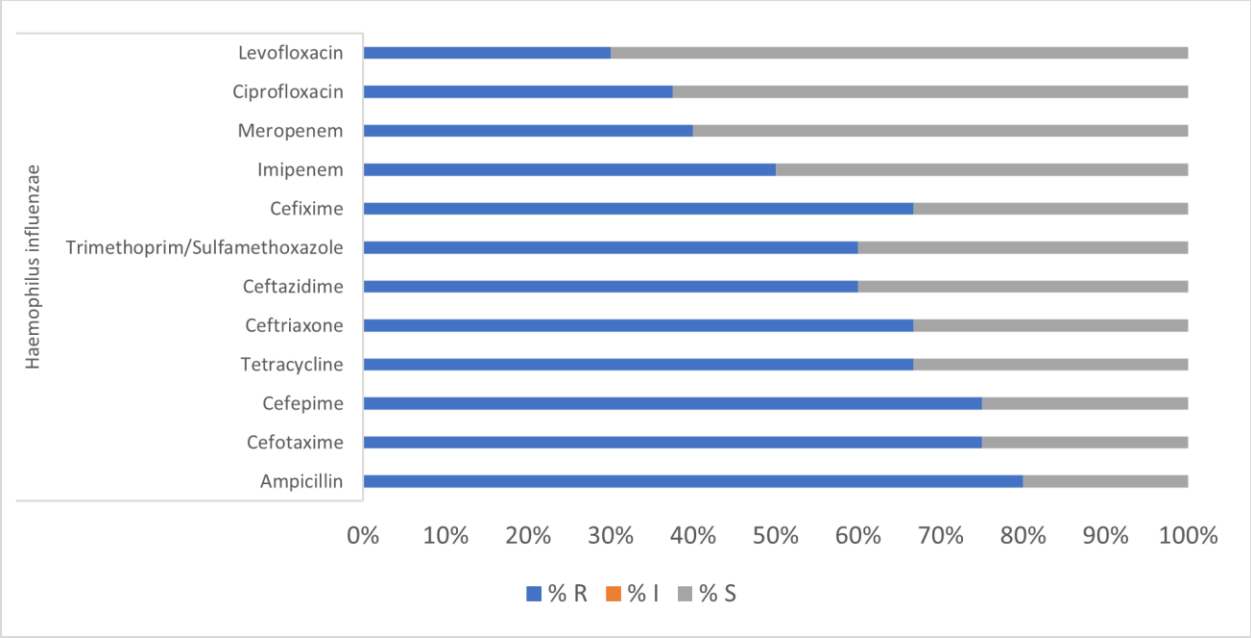
On the other hand, some antibiotics, such as cefotaxime, penicillin G, and tetracycline, show relatively lower resistance rates and a higher percentage of susceptibility. However, it is crucial to interpret these results cautiously, as the identity of the bacterium is not specified, and resistance patterns can vary depending on the specific bacterial species or strain.

The presence of intermediate susceptibility (%I) suggests that the effectiveness of these antibiotics in treating infections caused by the tested bacterium may be compromised. Intermediate susceptibility indicates that the antibiotic may have a reduced efficacy or that higher doses or combination therapy might be required for effective treatment.

3.9.11 Hemophilus influenza

Hemophilus influenzae is a Gram-negative bacterium that can cause various infections, including respiratory tract infections, meningitis, and otitis media. It is an important pathogen, especially in children and individuals with compromised immune systems. Understanding the characteristics and antibiotic resistance profile of Hemophilus influenzae is essential for guiding appropriate treatment and preventing the spread of resistant strains.

Figure (19): Percentages of Resistant, Intermediate, and Susceptible isolates for Haemophiles influenzae among isolates from all sources in Iraq, 2022



The data presented reveals the resistance profile of Hemophilus influenzae against various antibiotics.

Levofloxacin and Ciprofloxacin, fluoroquinolone antibiotics commonly used in the treatment of respiratory tract infections, demonstrated low resistance rates of 30% and 37.5% respectively. These resultsindicate the presence of significant resistance against these antibiotics in Hemophilus influenzae.

Meropenem and Imipenem, both belonging to the carbapenem class of antibiotics, showed resistance rates of 40% and 44.4%, respectively. Although still relatively effective compared to other antibiotics, the presence of resistance highlights the need for judicious use of these important antimicrobial agents.

Cefixime and Trimethoprim-sulfamethoxazole exhibited resistance rates of 50% and 60%, respectively. These results indicate a considerable level of resistance against these antibiotics. Careful consideration should be given to selecting alternative treatment options that demonstrate better efficacy.

Tetracycline demonstrated a resistance rate of 66.7%. Although this antibiotic still retains some effectiveness, caution should be exercised when considering its use. Resistance to Tetracycline suggests the presence of genetic factors that limit its efficacy against Hemophilus influenzae.

Cefepime and Cefotaxime exhibited similar resistance rates, both at 75%. These results indicate a significant level of resistance against these cephalosporin antibiotics. This highlights the importance of cautious prescribing practices and considering alternative treatment options when dealing with Hemophilus influenzae infections.

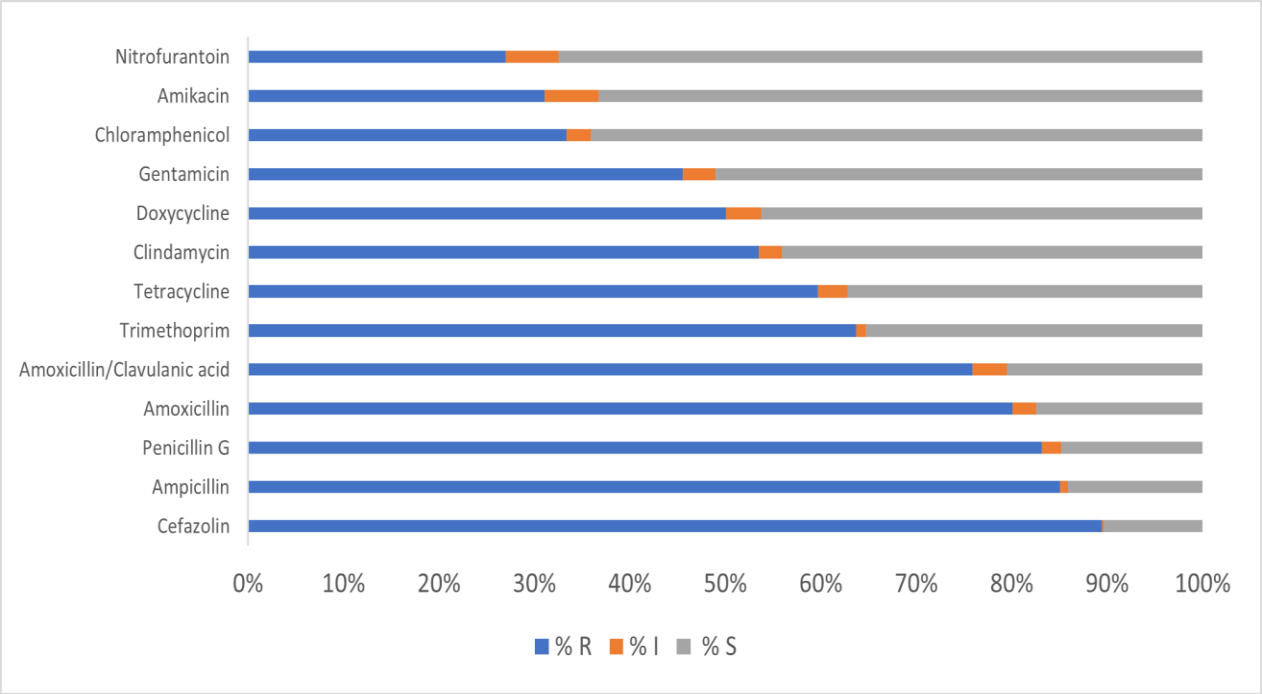
Ampicillin showed a high resistance rate of 80% against Hemophilus influenzae. This finding suggests that Ampicillin is not an effective choice for treating infections caused by this organism. Alternative antibiotics should be considered to ensure successful treatment.

Alternative treatment options should be considered when managing infections caused by this organism.

3.10 The AWaRe Classification of antibiotics

Antibiotics are classified into three groups, Access, Watch and Reserve, taking into account the impact of different antibiotics and antibiotic classes on antimicrobial resistance, to emphasize the importance of their appropriate use.

Figures (20): Percentages of Resistant profile for Access group antibiotics, Iraq, 2022



The presented data provides valuable information on the resistance patterns of several antibiotics commonly used in clinical practice. Understanding these patterns is crucial for guiding appropriate treatment choices and implementing effective strategies to combat antimicrobial resistance.

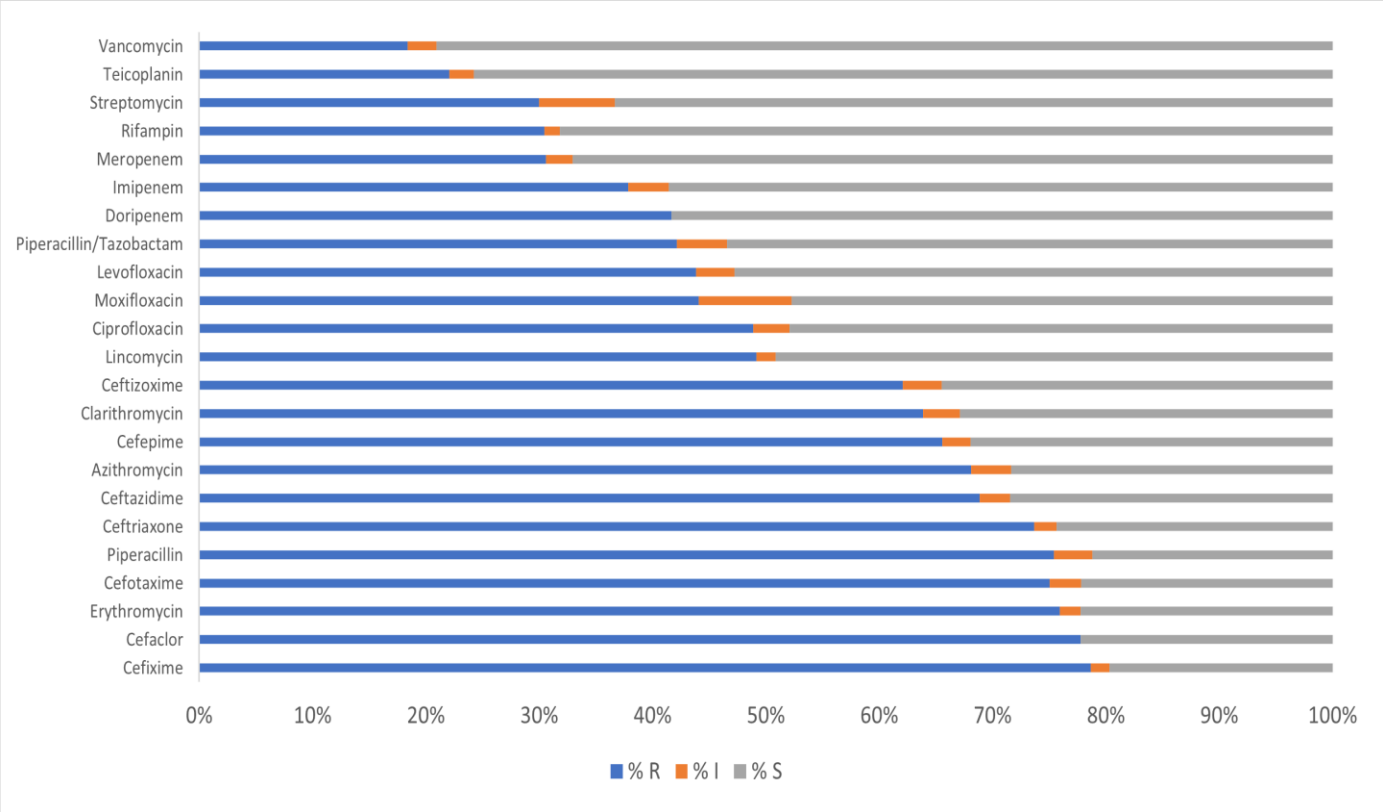
Among the antibiotics analyzed, Amoxicillin exhibited a relatively high resistance rate, with 80% of tested isolates being resistant. This finding emphasizes the limited efficacy of Amoxicillin as a standalone therapy for the tested organisms. Combination therapy with Clavulanic acid increased the susceptibility rate to 20%, suggesting the potential benefit of using Amoxicillin in combination with a β-lactamase inhibitor to enhance its effectiveness.

Ampicillin also demonstrated a high resistance rate, with 84% of tested isolates showing resistance. This highlights the limited utility of Ampicillin as a standalone treatment option for the tested organisms. Alternative antibiotics should be considered for infections where Ampicillin resistance is prevalent.

Cefazolin exhibited a relatively high resistance rate, with only 10% of tested isolates showing susceptibility. This indicates that Cefazolin remains un effective antibiotic choice for the tested organisms.

Among the tested antibiotics, Nitrofurantoin showed a notable susceptibility rate, with 67% of tested isolates being susceptible. This finding highlights the continued effectiveness of Nitrofurantoin as a treatment option for urinary tract infections caused by susceptible organism.

Figures (21): Percentages of Resistant profile for Watch group antibiotics, Iraq, 2022



The data presented in the table provide valuable insights into the resistance patterns of various antibiotics against tested organisms. A thorough analysis of these results can help inform treatment decisions and guide antimicrobial stewardship efforts.

Among the antibiotics examined, Vancomycin and Teicoplanin demonstrate notable susceptibility rates, with 79% and 76% of tested isolates showing susceptibility, respectively. These drugs remain effective treatment options for combating infections caused by susceptible organisms.

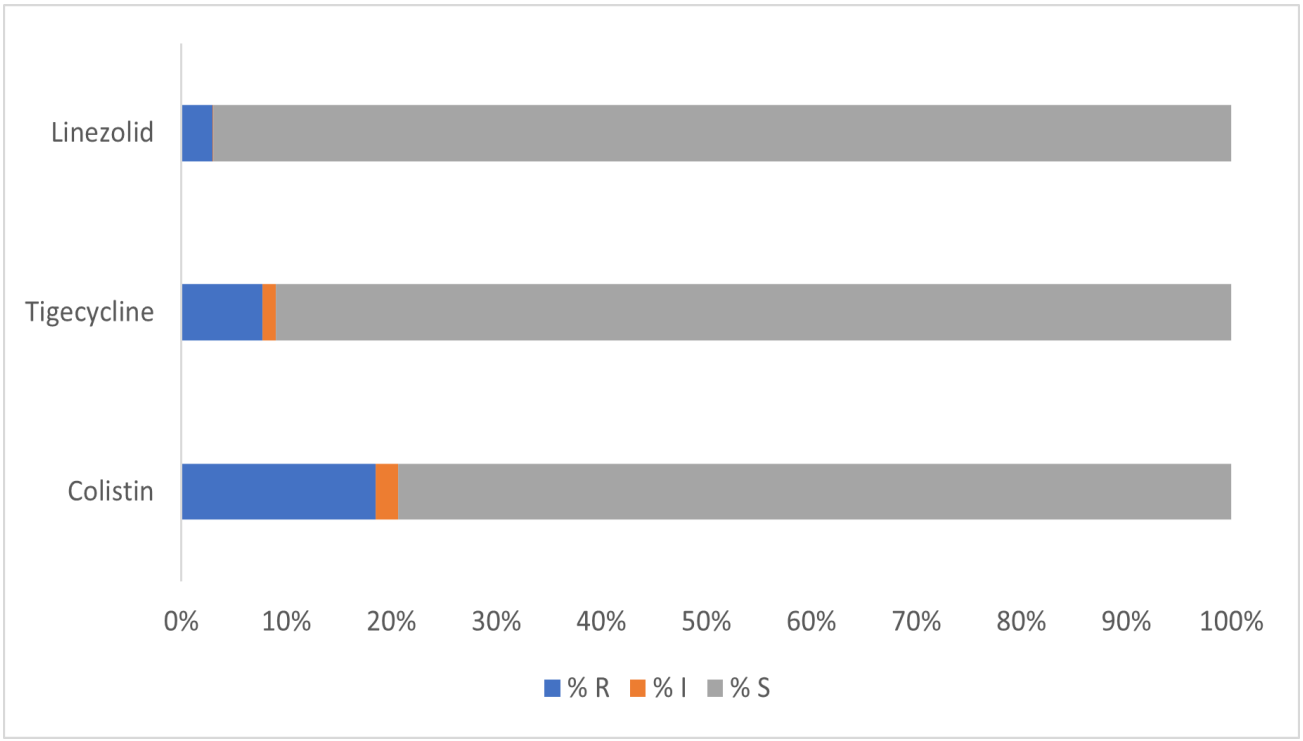
Streptomycin and Rifampin both exhibit moderate levels of resistance, with 63% and 68% of isolates showing susceptible, respectively. Although these antibiotics may still be viable treatment choices in certain cases, it is crucial to exercise caution when using them and consider alternative options whenever possible.

Meropenem and Imipenem display similar resistance rates, with 67% and 58% of tested isolates being susceptible, respectively. These findings underscore the importance of judicious use of carbapenems and the need for ongoing surveillance to monitor resistance trends.

Doripenem, Piperacillin/Tazobactam, Levofloxacin, Moxifloxacin, and Ciprofloxacin all demonstrate varying levels of resistance, ranging from 42% to 49%. This indicates that their effectiveness in treating infections caused by certain organisms may be compromised. Careful consideration should be given to the appropriateness of using these antibiotics, and alternative options should be explored whenever feasible.

Among the tested antibiotics, Ceftizoxime, Clarithromycin, Cefepime, Azithromycin, Ceftazidime, Ceftriaxone, Piperacillin, Cefotaxime, Erythromycin, Cefaclor, and Cefixime all show resistance rates more than 62%. These antibiotics may still be uneffective in treating certain infections

Figures (22): Percentages of Resistant profile for Reserve group antibiotics, Iraq, 2022.



The data provided in the table offers insights into the resistance patterns of three important antibiotics: Colistin, Tigecycline, and Linezolid. Understanding these resistance trends is crucial for informing treatment decisions and developing effective strategies to combat antimicrobial resistance.

Colistin, an antibiotic often considered as a last resort for multidrug-resistant infections, demonstrates a relatively low resistance rate of 18%. This indicates that the majority (79%) of tested isolates remain susceptible to Colistin. These findings highlight the continued efficacy of Colistin as a viable treatment option for infections caused by susceptible organisms.

Tigecycline, a broad-spectrum antibiotic frequently used for complicated infections, exhibits a higher susceptibility rate, with 91% of tested isolates showing susceptibility. This suggests that Tigecycline remains an effective therapeutic choice for a wide range of infections. However, it is important to note that continuous monitoring of resistance patterns is necessary to detect any potential changes over time.

Linezolid, a valuable antibiotic used primarily for treating Gram-positive infections, demonstrates an impressive susceptibility rate, with 97% of tested isolates being susceptible. These results confirm the continued effectiveness of Linezolid in treating infections caused by susceptible organisms and emphasize its importance in clinical practice

4. Discussion:

The presented report provides an overview of the antimicrobial resistance (AMR) situation in Iraq based on data collected through the Iraq AMR Surveillance System. The report highlights the widespread presence of antibiotic resistance in the country, with several priority pathogens showing high resistance rates. The data collected through surveillance serves as a valuable tool for understanding the epidemiology of AMR, trends, and guiding national AMR control policies.

One of the key findings of the report is the high prevalence of antibiotic resistance among critical and high-priority pathogens. Acinetobacter spp., Pseudomonas aeruginosa, and Escherichia coli, among others, show significant resistance to important antibiotics. This poses a serious challenge for healthcare providers in Iraq, limiting treatment options and increasing the risk of treatment failure and complications. The report's emphasis on these priority pathogens helps focus attention and resources on addressing the most pressing AMR concerns in the country.

Several factors have contributed to the rise of MRSA and 3rd-generation cephalosporin-resistant Escherichia coli in bloodstream infections. Overuse and misuse of antibiotics in healthcare settings, community environments, and agriculture have fueled the development of resistance mechanisms in these bacteria. Furthermore, inadequate infection control practices, limited access to diagnostics, and inappropriate prescribing practices have exacerbated the problem, enabling the dissemination and persistence of these resistant strains.

The report also highlights the importance of surveillance systems in combating AMR. The Iraq AMR Surveillance System, established in 2019, plays a crucial role in collecting and analyzing data from surveillance sites across the country. This data provides valuable insights into the extent and burden of AMR, helps identify emerging resistance patterns, and supports the development of evidence-based policies and interventions. By participating in the Global AMR Surveillance System (GLASS), Iraq

contributes to the global understanding of AMR and facilitates international collaboration in addressing this global health crisis.

It is essential to consider these results in the context of clinical guidelines, local antibiotic resistance patterns, and individual patient characteristics when choosing an appropriate antibiotic treatment for infections caused by resistance bacteria. Regular surveillance of antibiotic resistance is crucial to inform treatment decisions and guide efforts to combat antibiotic resistance.

It is important to note that the resistance profiles of each bacteria can vary regionally and over time. Antibiotic stewardship programs are crucial for monitoring and addressing resistance patterns. This information assists in selecting appropriate antibiotics and developing effective strategies to combat resistant.

5. Conclusion:

The comprehensive analysis of the AMR trends and resistance patterns in Iraq spanning the years 2019 to 2022 reveals a complex and evolving landscape of antimicrobial resistance. This period of observation has provided valuable insights into the changing dynamics of bacterial resistance, highlighting both areas of progress and concern.

Over this four-year span, the data demonstrates a positive trend of decreasing resistance among some key pathogens, such as Escherichia coli and MRSA. This is a promising sign that efforts to promote responsible antibiotic usage and infection control measures might be yielding results. However, these gains are contrasted by persistently high levels of resistance in some pathogens, indicating a continued need for robust interventions.

Furthermore, the analysis of resistance patterns across age groups and genders brings to light the need for targeted strategies. The differential resistance rates emphasize that approaches to combat AMR should consider demographic factors, tailoring interventions to address specific vulnerabilities.

The study's insights into specimen-specific resistance patterns emphasize the importance of considering the source of infection in treatment decisions. This underscores the significance of accurate diagnostics in guiding effective treatment plans, thereby reducing unnecessary antibiotic use.

The identification of priority pathogens with worrisome resistance levels to critical antibiotics demands immediate attention. This highlights the urgency of fostering research and development of novel antimicrobial agents and alternative therapeutic approaches.

This comprehensive report on AMR trends and resistance patterns in Iraq from 2019 to 2022 provides critical insights for healthcare authorities and policymakers. The findings underscore the urgency of implementing effective strategies to combat antimicrobial resistance and safeguard public health.

6. Recommendations:

Based on the findings and discussion presented in the report, several recommendations can be made to strengthen AMR control efforts in Iraq:

- Enhance antimicrobial stewardship programs: Implementing robust antimicrobial stewardship programs in healthcare facilities can help promote appropriate antibiotic use, reduce overprescribing, and minimize the development of resistance. These programs should focus on educating healthcare professionals about prudent antibiotic prescribing practices and promoting adherence to treatment guidelines.
- Improve infection prevention and control practices: Strengthening infection prevention and control measures, such as hand hygiene, sanitation, and proper disinfection protocols, can significantly reduce the transmission of antimicrobial-resistant microorganisms. Healthcare facilities should prioritize the implementation and monitoring of these practices to prevent healthcare-associated infections and limit the spread of resistance.
- Foster intersectoral collaboration: Addressing AMR requires a multi-sectoral approach involving various stakeholders, including healthcare providers, policymakers, veterinarians, agriculture sector, and the general public. Collaborative efforts should be encouraged to develop comprehensive strategies that encompass human health, animal health, and environmental aspects of AMR.
- Strengthen data collection and analysis: Continual improvement of the surveillance system is essential to track AMR trends, identify emerging threats, and assess the effectiveness of control measures. Regular training of personnel, and investment in laboratory infrastructure and capacity building are crucial to ensure high-quality data collection, analysis, and reporting.
- Raise awareness and promote education: Public awareness campaigns and educational initiatives targeting healthcare professionals, patients, and the general public can help raise awareness about AMR and promote responsible antibiotic use. This includes promoting the understanding that antibiotics are not effective against viral infections and emphasizing the importance of completing prescribed antibiotic courses to prevent the development of resistance.

By implementing these recommendations, Iraq can strengthen its efforts to combat AMR and mitigate its impact on public health. Collaboration with international partners, adherence to global guidelines, and continuous monitoring and evaluation will be essential in this endeavor. Addressing AMR

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