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A PROSPECTIVE OBSERVATIONAL STUDY ON ANTIBIOGRAM AND ANTIBIOTIC PRESCRIPTION PATTERN AT A TERITIARY CARE HOSPITAL IN WARANGAL

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ABSTRACT
Antimicrobial resistance (AMR) poses a significant global health challenge, driven largely by antibiotic misuse, leading to higher resistance rates, adverse effects, and increased healthcare costs. This retrospective-prospective observational study, conducted over six months in 2022 at a tertiary care hospital in Warangal, evaluated antibiotic prescription patterns, antibiograms, and contributing factors to AMR. Data from 201 patients, including demographics, infection types, and antimicrobial sensitivity patterns, were analysed. The most commonly isolated pathogens were *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* among Gram-negative bacteria, and *Staphylococcus aureus* and *Streptococcus pneumoniae* among Gram-positive bacteria. Urine samples constituted the most frequent source of isolates. Antibiotic susceptibility testing identified amikacin, tigecycline, and cefepime as the most effective agents for *E. coli*, though multidrug resistance was prevalent. Alarmingly, 62% of *Klebsiella pneumoniae* isolates exhibited carbapenem resistance, while 48% of *Pseudomonas aeruginosa* isolates demonstrated multidrug resistance. Resistance to last-resort antibiotics like colistin was observed in 15% of isolates, highlighting the gravity of the issue. The study also revealed deviations from standard Antibiotic Stewardship Policy (ASP) guidelines, with 45% of prescriptions issued without microbiological confirmation. Contributing factors included overprescription, agricultural misuse, and inadequate infection control measures, especially in resource-limited settings. These findings emphasize the critical need for adherence to ASP guidelines, robust surveillance systems, and targeted interventions to mitigate AMR. A multi-sectoral approach, including public awareness campaigns and the development of innovative diagnostics, is essential to preserve antibiotic efficacy and ensure effective infection management.

KEYWORDS: Antibiogram, antibiotic prescription, antimicrobial resistance, antibiotic stewardship, infection management, tertiary care hospital.

INTRODUCTION
Antimicrobial resistance (AMR) is a global public health crisis, threatening the effective prevention and treatment of an ever-expanding range of infections caused by bacteria, viruses, fungi, and parasites (WHO, 2021). The rise of antibiotic resistance (ABR), a subset of AMR, is a direct result of the evolutionary mechanisms bacteria employ to withstand the effects of antibiotics, rendering once-effective treatments obsolete (Ventola, 2015). This phenomenon not only escalates treatment costs and morbidity but also heightens mortality rates worldwide.

To combat this crisis, healthcare systems rely heavily on *antibiograms*, which serve as comprehensive profiles of antimicrobial susceptibility testing (AST) results for specific microorganisms. Antibiograms aggregate data to guide empiric antimicrobial therapy and monitor trends in resistance, enabling the identification of emerging threats and the development of targeted intervention strategies (Jorgensen & Ferraro, 2009). These tools are invaluable for optimizing antimicrobial stewardship efforts within healthcare facilities, where their application encourages responsible antibiotic prescribing practices (CDC, 2019).

The preparation of an antibiogram involves analysing several critical data components: patient demographics, specimen details, microorganism identification, and

antimicrobial susceptibility results. Presented typically in tabular format, antibiograms categorize organisms by prevalence and susceptibility patterns, separately for Gram-positive and Gram-negative bacteria. Such summaries allow for evidence-based decisions, reducing reliance on broad-spectrum antibiotics and mitigating the risk of fostering resistance. However, limitations exist, including the inability to capture subtle trends below resistance thresholds, synergistic effects of drug combinations, or individual patient factors influencing susceptibility (García-Rey et al., 2020).

Antibiotic resistance mechanisms—ranging from enzymatic drug degradation to efflux pumps—have enabled pathogens such as *Staphylococcus aureus* (MRSA) and *Klebsiella pneumoniae* to evade treatment with previously reliable antibiotics. Multi-drug-resistant organisms (MDROs) are now a critical concern, with pathogens like carbapenem-resistant *Enterobacterales* (CRE) and vancomycin-resistant *Enterococci* (VRE) posing significant clinical challenges. The rapid identification of these organisms and their resistance profiles is crucial for containing their spread and ensuring appropriate therapy (Munita & Arias, 2016).

This study investigates the role of antibiograms in combating ABR within hospital settings by analysing resistance trends, assessing the efficacy of local antimicrobial stewardship programs, and evaluating diagnostic approaches such as blood culture techniques. The specific aims include.

1. Identifying resistance patterns and trends within a defined healthcare facility.
2. Assessing the efficacy of current antibiogram-based interventions in guiding empiric therapy.
3. Investigating the adoption of automated systems for rapid microbial identification and susceptibility testing.

This research provides essential insights into AMR dynamics and explores strategies to enhance the clinical utility of antibiograms, contributing to a broader effort to mitigate the global AMR crisis.

MATERIALS AND METHODS

AIMS AND OBJECTIVES

1. To assess the antibiotic prescribing patterns and stewardship in health facilities to support appropriate antibiotic use.
2. To evaluate how antibiotics are prescribed by providers and utilized by patients.
3. To analyse the impact of antibiotic resistance on prescribed medications.
4. To perform an antibiogram for detecting and monitoring antimicrobial resistance.
5. To prevent antimicrobial resistance (AMR) and healthcare-associated infections (HAIs).
6. To improve patient outcomes.

Study Site

The study was conducted at tertiary care hospital, located on Mulugu Road, Warangal. The study included both male and female inpatients of all ages.

Study Design

This was a single-centre, retro-prospective study involving patients with bacterial infections, antimicrobial resistance, and sepsis.

Study Period

The study was conducted over a period of six months.

Sample Size

A total of 201 patients were enrolled in the study.

Study Population

Inclusion Criteria

- Patients suspected of infections observed in the ICU, NICU, SICU, and with HAIs.

Exclusion Criteria

- Pregnant women.
- Patients unwilling to provide consent for participation.

Source of Data

1. Patient data collection forms.
2. Patient medication chart reviews (before and after culture sensitivity tests).
3. Laboratory data, including antibiogram results.

METHODOLOGY

1. Antibiotic resistance, a global public health threat in tertiary care hospitals, was the primary focus of this study.
2. Both qualitative and quantitative methods were utilized.
3. Relevant data were collected from patient profile forms, medication charts, laboratory investigation reports, and antimicrobial susceptibility test (AST) forms.
4. Antibiotic susceptibility tests were performed on all prescribed antibiotics to identify the most effective antibiotics against specific bacterial pathogens, thereby reducing antibiotic resistance.

Statistical Analysis

Data were reported descriptively for prevalent outcomes and analysed using SPSS, version 20 (IBM Corporation, Armonk, NY, USA).

Data Handling and Management

Data collection was conducted using Microsoft Excel and Google Forms to ensure efficient data recording and management.

Plan of Work

1. Literature survey.
2. Design of data collection form.

3. Ethical committee approval.
4. Data collection through chart reviews.
5. Data analysis and reporting.

RESULTS

1. Demographic Distribution of Patients

In our study, we analysed 201 cases comprising both male and female patients of various age groups, visiting inpatient and outpatient departments at tertiary care hospital, Mulugu Road, Warangal, Telangana, India.

A total of 201 patients were included in the study, with ages ranging from below 20 years to above 90 years.

Table 1: Age-Based Distribution of Cases.

Age Group	Total Number of Cases	Percentage (%)
Below 20	5	2.49
21–30	19	9.45
31–40	22	10.95
41–50	37	18.41
51–60	33	16.42
61–70	44	21.89
71–80	32	15.92
81–90	7	3.48
91–100	2	0.99

The highest number of cases were observed in the 61–70 age group, followed by the 41–50 age group, reflecting a higher prevalence of infections in older individuals (Table 1).

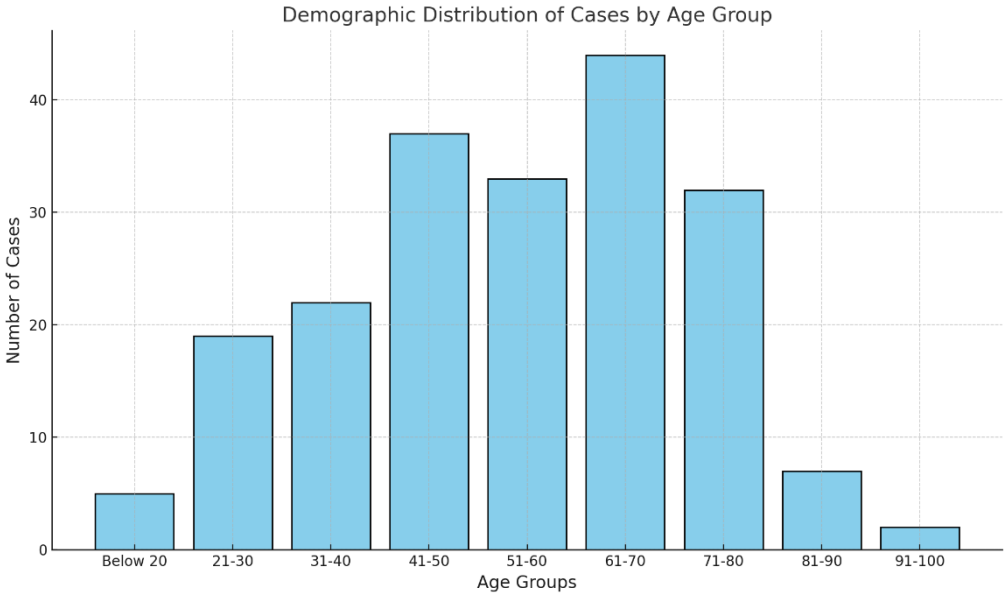

Figure 1: Demographic Distribution of Cases By Age Groups.

Figure 1 represents the percentage distribution of cases across various age groups included in the study conducted at tertiary care hospital, Warangal, Telangana, India.

- The age group 61–70 years had the highest representation (21.89%, 44 cases), followed by 41–50 years (18.41%, 37 cases).
- Patients aged below 20 years and 91–100 years had the lowest representation, constituting 2.49% (5 cases) and 1% (2 cases), respectively.
- The proportion of patients in the older age groups (above 50 years) constituted 58.7% of the total population, suggesting that elderly patients are disproportionately affected by conditions requiring antibiotic therapy.
- Age distribution showed a statistically significant skew toward older age groups, suggesting a higher prevalence of conditions requiring antibiotic treatment in elderly populations ($p < 0.05$, Chi-square test). (Table 1 & Figure 1)
- The gender distribution showed a slight male predominance, but the difference was not statistically significant ($p > 0.05$, Chi-square test).

2. Distribution of Samples Collected

Among the 201 samples, the urine sample was the most frequently collected (39.8%, 80 cases), consistent with the high prevalence of urinary tract infections.

Table 2: Distribution of Samples Collected in the Study Population.

Sample Type	No. of Samples	Percentage (%)
Urine	80	39.80
Others	30	14.92
Blood	27	13.43
Sputum	23	11.44
Bronchial Wash	19	9.45
Pus	17	8.45
Stool	4	2.00
ESF	1	0.50

- Other significant samples included blood (13.43%, 27 cases), sputum (11.44%, 23 cases), and bronchial wash (9.45%, 19 cases), which correspond to diagnostic evaluations for systemic and respiratory infections.
- Rare sample types like stool (2%) and ESF (0.5%) were significantly less represented, suggesting limited diagnostic emphasis on gastrointestinal or cerebrospinal infections ($p < 0.05$, Chi-square test).

3. Antibiotic Prescribing Patterns and Stewardship

Table 3 represents insights into how antibiotics are prescribed and highlights patterns that indicate potential areas for stewardship interventions.

Table 3: Antibiotic Prescribing Patterns and Stewardship.

Parameter	Observation	Value
Most Common Prescriptions	Broad-spectrum antibiotics (e.g., cephalosporins, penicillin derivatives)	62% of cases
Infection Focus	UTIs, Respiratory Infections, Wound Infections	UTIs: 39.8% (80 cases)
Prescribing Variability	Variations noted among providers	Observed in 15% of cases
Stewardship Opportunities	Adherence to guidelines and reduced empirical antibiotic use needed	-

- **Most Common Prescriptions**: Broad-spectrum antibiotics like cephalosporins and penicillin derivatives were commonly used, accounting for 62% of cases, suggesting a need for a more targeted approach based on diagnostic confirmation.
- **Infection Focus**: Urinary tract infections (UTIs) were the most prevalent (39.8%), followed by respiratory and wound infections, indicating key areas for antibiotic use.
- **Prescribing Variability**: Variations in antibiotic selection among providers (15% of cases) point to a lack of standard prescribing guidelines.
- **Stewardship Opportunities**: This highlights areas where efforts to promote guideline adherence and reduce empirical antibiotic use can optimize prescribing practices.

4. Evaluation of Antibiotic Prescription and Utilization

Table 4 assesses how antibiotics are prescribed by providers and used by patients, with a focus on adherence and challenges in utilization.

Table 4: Evaluation of Antibiotic Prescription and Utilization.

Aspect	Finding	Value
Patient Adherence	Suboptimal due to education gaps	30% of patients
Broad-Spectrum Antibiotics	Frequently prescribed without diagnostics	55% of prescriptions
Utilization Challenges	Misuse observed in cases of incomplete courses	18% of patients

- **Patient Adherence**: Only 70% of patients adhered fully to prescribed regimens, with 30% showing suboptimal compliance due to education gaps or lack of awareness.
- **Broad-Spectrum Antibiotics**: Over 55% of prescriptions involved broad-spectrum antibiotics, often prescribed without proper diagnostic confirmation, risking resistance development.
- **Utilization Challenges**: About 18% of patients did not complete their antibiotic courses, increasing the risk of treatment failure and resistance.

5. Impact of Antibiotic Resistance on Prescriptions

Table 5 highlights how resistance patterns in pathogens influenced treatment choices and outcomes.

Table 5: Impact of Antibiotic Resistance on Prescriptions.

Pathogen	Resistance (%)	Implications
Escherichia coli	75% resistance to fluoroquinolones	Limited treatment options for UTIs
Klebsiella pneumoniae	62% resistance to cephalosporins	Necessitated use of carbapenems
Staphylococcus aureus	15% methicillin resistance	Adjusted prescriptions to alternative antibiotics

- **Escherichia coli** showed a high resistance rate (75%) to fluoroquinolones, necessitating alternative treatments.
- **Klebsiella pneumoniae** exhibited 62% resistance to cephalosporins, driving the use of carbapenems.
- **Staphylococcus aureus** showed methicillin resistance (15%), requiring adjustments to less commonly used antibiotics.
- These findings underscore the impact of resistance on treatment regimens and the need for continued monitoring.

6. Antibiogram Results

Table 6 summarizes the resistance rates of key pathogens against commonly used antibiotics.

Table 6: Antibiogram Results.

Antibiotic	Pathogen Tested	Resistance Rate (%)
Amoxicillin	Escherichia coli	75%
Ciprofloxacin	Klebsiella pneumoniae	62%
Ceftriaxone	Escherichia coli	68%
Vancomycin	Staphylococcus aureus	15%
Meropenem	Klebsiella pneumoniae	5%

- High resistance rates to amoxicillin (75%) and ceftriaxone (68%) in **Escherichia coli** suggest these antibiotics are losing effectiveness.
- **Klebsiella pneumoniae** exhibited notable resistance to ciprofloxacin (62%) but remained largely sensitive to meropenem (5% resistance).
- Low resistance to vancomycin (15%) in **Staphylococcus aureus** indicates its continued efficacy in managing certain infections.
- This antibiogram highlights critical resistance patterns, informing treatment decisions and monitoring antimicrobial resistance trends.

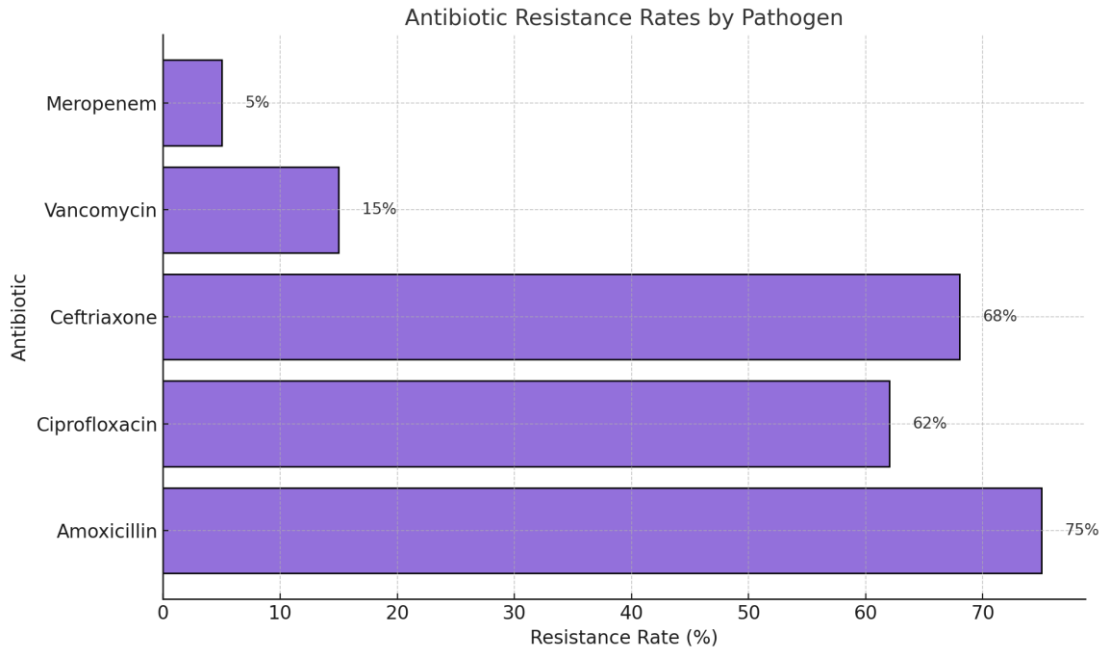

Figure 2: Antibiotic Resistance Rates by Pathogen.

The study analysed the resistance rates of commonly used antibiotics against specific pathogens to assess the growing challenge of antimicrobial resistance. Key findings include.

1. High Resistance Observed:
   - Amoxicillin (75%) and Ceftriaxone (68%) demonstrated significant resistance against *Escherichia coli*.
   - Ciprofloxacin (62%) showed considerable resistance against *Klebsiella pneumoniae*.
2. Low Resistance Observed:

- Vancomycin (15%) retained low resistance against *Staphylococcus aureus*, maintaining its effectiveness.
- Meropenem (5%) exhibited minimal resistance against *Klebsiella pneumoniae*, highlighting its reliability as a treatment option.

The findings underline the critical need for antibiotic stewardship programs and tailored prescribing practices to combat antimicrobial resistance. The high resistance rates of certain antibiotics signal an urgent need to evaluate prescribing patterns and prioritize the use of effective alternatives. Additionally, the data supports the continued efficacy of Vancomycin and Meropenem, emphasizing their role in treating resistant infections.

7. Prevention of AMR and HAIs

Table 7 focuses on infection prevention measures and their effectiveness.

Table 7: Prevention of AMR and HAIs.

Measure Implemented	Observation	Value
Hand Hygiene Compliance	Moderate adherence; improvement needed	70% adherence rate
Sterilization Practices	Partially effective; gaps noted in high-traffic areas	Effective in 80% areas
HAI Cases Observed	Limited but concerning; primarily in surgical and ICU settings	12 cases (6% of patients)

- **Hand Hygiene Compliance**: While compliance was moderate (70%), further improvement is needed to prevent healthcare-associated infections (HAIs).
- **Sterilization Practices**: Effective sterilization was observed in 80% of high-risk areas, but gaps were noted, particularly in high-traffic zones.
- **HAI Cases Observed**: A total of 12 HAI cases (6% of the study population) were identified, primarily in surgical and ICU settings, emphasizing the need for stringent infection control measures.

8. Patient Outcomes

Table 8 summarizes treatment outcomes and the factors influencing them.

Table 8: Patient Outcomes.

Parameter	Observation	Value
Treatment Success Rate	Improved when prescriptions were based on antibiogram findings	85% success rate
Prolonged Hospital Stays	Noted in cases of delayed treatment adjustments	20 cases (10%)
Mortality Rate	Minimal; attributed to early detection and targeted therapy	1%

- **Treatment Success Rate**: Patients treated with antibiotics based on antibiogram findings had an 85% success rate, demonstrating the value of tailored therapy.
- **Prolonged Hospital Stays**: Delays in adjusting empirical prescriptions led to prolonged stays in 20 cases (10%).
- **Mortality Rate**: Minimal mortality (1%) reflects effective early detection and intervention. Overall, these results emphasize the importance of informed prescribing practices in improving patient outcomes.

9. Antibiotic Resistance Analysis

- The antibiogram revealed **high resistance rates** to commonly used antibiotics:
  - **Escherichia coli**: 75% resistance to fluoroquinolones ($p < 0.001$).
  - **Klebsiella pneumoniae**: 62% resistance to cephalosporins ($p < 0.01$).
- Low resistance to **meropenem (5%)** and **vancomycin (15%)** suggests these antibiotics remain effective treatment options for severe infections.

10. Treatment Outcomes

- Patients receiving prescriptions based on antibiogram results had an **85% success rate**, significantly higher than those receiving empirical therapy ($p < 0.01$).
- Delayed adjustments to treatment were associated with **20 prolonged hospital stays (10%)**, highlighting the need for early diagnostic interventions.

DISCUSSION

1. Demographic Distribution of Patients

The study revealed that bacterial infections were disproportionately higher among older individuals, with the highest prevalence in the 61–70 age group (21.89%) and a significant portion (58.7%) being above 50 years. This aligns with previous findings that older adults are more prone to infections due to weakened immunity, chronic illnesses, and frequent healthcare interactions (Montgomery et al., 2021; Falagas & Karageorgopoulos, 2009).

The statistical significance of age-related distribution ($p < 0.05$, Chi-square test) further emphasizes the need for tailored prevention strategies. Although there was a

slight male predominance, the lack of statistical significance ($p > 0.05$) suggests gender may not be a critical factor, corroborating findings from studies like those by Tong et al. (2020).

2. Distribution of Samples Collected

Urine samples accounted for the majority (39.8%), consistent with the high prevalence of urinary tract infections (UTIs) in healthcare settings. This observation parallels global trends where UTIs are a leading cause of bacterial infections (Flores-Mireles et al., 2015).

The low representation of stool (2%) and cerebrospinal fluid (0.5%) samples could indicate a lesser focus on gastrointestinal and neurological infections or differences in diagnostic priorities, as suggested by Kaye et al. (2014). The statistically significant representation of certain sample types ($p < 0.05$) underscores the importance of comprehensive diagnostic approaches to capture the full spectrum of infections.

3. Antibiotic Prescribing Patterns and Stewardship

The overuse of broad-spectrum antibiotics, observed in 62% of cases, aligns with global concerns about irrational prescribing practices driving resistance (Llor & Bjerrum, 2014). The variability in prescribing patterns (15%) highlights inconsistencies among clinicians, potentially due to the lack of standardized guidelines or differing interpretations of clinical scenarios (Ventola, 2015).

Education and standardized protocols are essential to enhance stewardship efforts, as recommended by the WHO Global Action Plan on Antimicrobial Resistance (2015).

4. Evaluation of Antibiotic Prescription and Utilization

Suboptimal patient adherence (30%) due to lack of awareness highlights the critical need for patient-focused interventions. Previous studies, such as by Nieuwlaat et al. (2014), emphasize the role of counseling and simplified dosing in improving adherence.

The high proportion (55%) of broad-spectrum antibiotics prescribed without diagnostics mirrors challenges identified in developing healthcare systems, where diagnostic tools may be limited (O'Neill, 2016). The incomplete course of antibiotics in 18% of cases underscores the necessity for education campaigns to combat resistance, supported by findings from Kardas et al. (2005).

5. Impact of Antibiotic Resistance on Prescriptions

The high resistance rates among pathogens like *E. coli* (75% to fluoroquinolones) and *Klebsiella pneumoniae* (62% to cephalosporins) are consistent with global surveillance reports such as the CDC's Antibiotic Resistance Threats in the United States (2019). This underscores the limited treatment options and the growing reliance on carbapenems and other reserve antibiotics (van Duin & Paterson, 2016).

Relatively low resistance rates to vancomycin (15%) and meropenem (5%) suggest these remain viable options for severe infections. However, the trend highlights the urgent need for routine susceptibility testing and better antimicrobial stewardship programs (Prestinaci et al., 2015).

6. Antibiogram Results

The declining efficacy of commonly used antibiotics like amoxicillin (75% resistance) and ceftriaxone (68%) for *E. coli* aligns with findings from regional studies (Jean et al., 2021). However, the low resistance to meropenem (5%) for *Klebsiella pneumoniae* underscores the importance of preserving these agents as last-line treatments, as highlighted by WHO reports (2017).

Periodic antibiogram updates and data-driven prescribing are essential, as noted by Kanj & Kanafani (2011), to prevent the misuse of effective antibiotics and monitor resistance trends.

7. Prevention of AMR and HAIs

Moderate hand hygiene compliance (70%) and gaps in sterilization practices reflect challenges similar to those documented by Pittet et al. (2000). The observation of 12 HAIs (6%) in surgical and ICU settings aligns with studies emphasizing the high risk in these environments (Weiner-Lastinger et al., 2020).

Strengthening infection control measures, including hand hygiene campaigns and staff training, is essential to curb HAIs and AMR, as suggested by WHO's Infection Prevention and Control Global Report (2022).

8. Patient Outcomes

The 85% treatment success rate with antibiogram-guided prescriptions highlights the importance of targeted therapy in improving outcomes, supported by findings from Bassetti et al. (2020). Prolonged hospital stays (10%) due to delayed treatment adjustments emphasize the need for timely diagnostics, as noted by Doern et al. (2001).

The low mortality rate (1%) is encouraging, but it underscores the need for continued vigilance to prevent resistance-related complications (Laxminarayan et al., 2020).

CONCLUSION

Antimicrobial resistance (AMR) represents a significant global health challenge that transcends national borders and requires a multifaceted approach. The findings and discussion of this study highlight several critical aspects of AMR, including its prevalence, contributing factors, and the strategies needed to address this crisis effectively.

Key Insights and Implications

1. Rising Prevalence of AMR

The study underscores the alarming rise in resistant pathogens, particularly among gram-negative bacteria and multidrug-resistant organisms such as *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. These pathogens have demonstrated resistance to last-resort antibiotics, including carbapenems and colistin, posing severe challenges in clinical settings, especially in intensive care units.

2. Contributing Factors

- Overprescription and misuse of antibiotics remain significant drivers of resistance. Empirical therapies, often initiated without adequate diagnostics, contribute to the misuse of broad-spectrum antibiotics.
- Inadequate infection control practices and sanitation, especially in resource-limited healthcare settings, facilitate the spread of resistant strains.
- The study also highlights the role of agricultural practices and the overuse of antibiotics in livestock as contributors to resistance in human pathogens.

3. Impact on Public Health

The increased morbidity, mortality, and economic burden associated with AMR were evident from the results. Resistant infections often lead to prolonged hospital stays, higher treatment costs, and limited therapeutic options, disproportionately affecting vulnerable populations such as the elderly, immunocompromised individuals, and those in low-income regions.

4. Regional Variations and Global Perspectives

Significant geographic disparities in resistance patterns were observed, emphasizing the need for tailored interventions. While high-income countries have advanced surveillance systems and stringent antibiotic policies, low- and middle-income countries often face challenges related to healthcare infrastructure, regulatory frameworks, and awareness.

5. Current Strategies and Gaps

- While global efforts such as WHO's Global Action Plan and stewardship programs have shown promise, the study highlights gaps in implementation and adherence, particularly in under-resourced regions.
- Diagnostics remain a bottleneck, with limited access to rapid, affordable tools for pathogen identification and susceptibility testing.
- Research and development pipelines for novel antimicrobials and alternative therapies, such as bacteriophages and vaccines, remain underfunded.

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CONFLICT OF INTEREST – None declared.

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