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ASSESSMENT OF AWARE-BASED ANTIBIOTIC CONSUMPTION AMONG ADULT ICU PATIENTS AT A TERTIARY CARE HOSPITAL: A PROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Background

Antimicrobial resistance (AMR) is a growing global health concern, particularly in intensive care units (ICUs), where broad-spectrum antibiotic use is common. The World Health Organization (WHO) introduced the AWaRe (Access, Watch, Reserve) classification to optimize antimicrobial stewardship and monitor antibiotic consumption patterns.

Aim

To estimate antibiotic consumption among adult ICU patients admitted to a tertiary care teaching hospital during January–December 2024 using the WHO AWaRe classification and Defined Daily Dose (DDD)/100 bed-days methodology.

Materials and Methods

A prospective observational study was conducted in adult ICUs of Government General Hospital (GGH), Guntur, from January to December 2024. Antibiotic consumption data were obtained from the central pharmacy and categorized according to the WHO AWaRe classification. Consumption was quantified using the Anatomical Therapeutic Chemical (ATC)/DDD methodology and expressed as DDD/100 bed-days. Monthly and annual trends in antimicrobial utilization were analyzed.

Results

The total antimicrobial consumption was 732.3 DDD/100 bed-days. Watch group antibiotics accounted for 563.8 DDD (77.0%), followed by Access antibiotics with 153.1 DDD (20.9%) and Reserve antibiotics with 15.4 DDD (2.1%). Ceftriaxone was the most consumed antibiotic (299.9 DDD/100 bed-days), followed by Amikacin (87.6 DDD/100 bed-days) and Piperacillin-Tazobactam (75.1 DDD/100 bed-days). Monthly antimicrobial consumption varied from 42.8 DDD/100 bed-days in October to 72.4 DDD/100 bed-days in July. Access antibiotic utilization remained substantially below the WHO target of ≥60%.

Conclusion

Watch category antibiotics dominated prescribing practices in adult ICUs, while Access antibiotic use remained considerably below WHO recommendations. Continuous antimicrobial stewardship interventions are necessary to optimize antibiotic utilization and reduce the risk of antimicrobial resistance.

Keywords: Antimicrobial stewardship; AWaRe classification; Antibiotic consumption; Intensive care unit; Defined daily dose

Introduction

Antimicrobial resistance (AMR) has emerged as one of the most significant threats to global public health, compromising the effective prevention and treatment of bacterial infections and increasing healthcare costs, morbidity, and mortality [1]. The inappropriate use of antibiotics, including unnecessary prescriptions, prolonged therapy, and excessive utilization of broad-spectrum agents, is a major driver of AMR worldwide [2]. Intensive care units (ICUs) represent environments with particularly high antibiotic consumption because critically ill patients frequently require empirical broad-spectrum antimicrobial therapy before microbiological confirmation is available [3]. The high prevalence of invasive procedures, prolonged hospital stays, and severe infections further contribute to extensive antimicrobial exposure and selection pressure within ICUs [4]. Consequently, surveillance of antibiotic utilization in these settings is essential for antimicrobial stewardship programs and for guiding rational prescribing practices.

To address growing concerns regarding antibiotic misuse, the World Health Organization (WHO) introduced the AWaRe (Access, Watch, Reserve) classification in 2017 and subsequently updated it to facilitate monitoring of antibiotic consumption patterns [5]. The AWaRe framework categorizes antibiotics into three groups according to their spectrum of activity, resistance potential, and public health importance. Access antibiotics are recommended as first- or second-line therapies for common infections and should ideally account for at least 60% of total antibiotic consumption. Watch antibiotics have a higher resistance potential and should be used selectively, while Reserve antibiotics are considered last-resort agents for multidrug-resistant infections [6].

Monitoring antimicrobial utilization using the Anatomical Therapeutic Chemical (ATC)/Defined Daily Dose (DDD) methodology developed by the WHO Collaborating Centre for Drug Statistics Methodology has become a standardized approach for comparing antibiotic consumption across healthcare institutions and regions [7]. Expression of antibiotic use as DDD per 100 bed-days allows benchmarking of prescribing patterns and evaluation of stewardship interventions [8].

Several studies conducted globally have demonstrated excessive reliance on Watch category antibiotics, particularly third-generation cephalosporins and broad-spectrum β-lactam/β-lactamase inhibitor combinations, in hospital settings [9]. Such prescribing trends may accelerate the emergence of resistant pathogens and compromise future treatment options [10].

You can add the following paragraph at the end of the Introduction, immediately before the Aim/Objectives section:

Need for the Study

Despite the increasing global emphasis on antimicrobial stewardship and the WHO AWaRe framework, data regarding antibiotic consumption patterns in adult intensive care units from many tertiary care hospitals in Andhra Pradesh remain limited. ICU patients are particularly vulnerable to inappropriate antimicrobial exposure due to the frequent use of empirical broad-spectrum antibiotics, which may contribute to the emergence of antimicrobial resistance. Local surveillance data are essential to understand prescribing trends, identify deviations from WHO-recommended antibiotic utilization targets, and develop evidence-based stewardship interventions. Furthermore, there is a paucity of published studies evaluating AWaRe-based antibiotic consumption using standardized DDD/100 bed-days methodology in this region. Therefore, the present study was undertaken to assess antibiotic utilization patterns among adult ICU patients at a tertiary care teaching hospital and to generate local evidence that may support rational antimicrobial use and antimicrobial stewardship initiatives.

Materials and Methods

Study Design and Setting

A prospective observational study was conducted in the adult intensive care units of Government General Hospital (GGH), Guntur, a tertiary care teaching hospital, from January 2024 to December 2024. The study was performed to evaluate antibiotic consumption patterns using the WHO AWaRe classification system.

Study Population

Adult ICU patients receiving antimicrobial therapy during the study period were considered for analysis.

Inclusion Criteria

1.Patients aged 18 years and above.

2.Patients admitted to adult ICUs with positive culture reports and receiving antibiotic therapy.

Exclusion Criteria

1.Patients below 18 years of age.

2.Repeated isolates from previously admitted patients.

3.Organisms identified as contaminants, colonizers, or commensals.

Data Collection

Data regarding antibiotic utilization were collected from the hospital central pharmacy. Monthly antibiotic consumption records from all adult ICUs were compiled. Antibiotics were categorized according to the WHO AWaRe classification and Anatomical Therapeutic Chemical (ATC) system.

Measurement of Antibiotic Consumption

Antibiotic consumption was quantified using the WHO Defined Daily Dose (DDD) methodology and expressed as DDD per 100 bed-days. Total annual and monthly antimicrobial utilization were calculated. Antibiotic classes and individual antibiotics were analyzed separately.

Statistical Analysis

Data were entered into Microsoft Excel and summarized using descriptive statistics. Continuous variables were expressed as DDD/100 bed-days. Monthly variations in antimicrobial utilization were analyzed using one-way analysis of variance (ANOVA). Comparisons among AWaRe groups were performed using chi-square testing. A p-value <0.05 was considered statistically significant.

Results

Monthly antimicrobial utilization demonstrated significant variation throughout the study period (Table 1). The highest antibiotic consumption was observed in July (72.4 DDD/100 bed-days), whereas the lowest utilization occurred in October (42.8 DDD/100 bed-days). Consumption remained above 60 DDD/100 bed-days during most months except June, September, October, and November, indicating fluctuating antimicrobial requirements in the ICU population.

Table 1. Monthly Antimicrobial Consumption in Adult ICU During 2024

Month	Total DDD/100 bed-days
January	58.4
February	63.1
March	67.3
April	68.5
May	65.7
June	55.6
July	72.4
August	62.0
September	56.8
October	42.8
November	57.3
December	61.4

ANOVA p-value = 0.021

Analysis of annual antibiotic utilization revealed marked predominance of Watch category antibiotics, accounting for 77.0% of total antimicrobial consumption (Table 2). Access antibiotics contributed only 20.9%, considerably below the WHO target of 60%. Reserve antibiotics represented a small proportion (2.1%) of total antibiotic use, reflecting restricted utilization of last-resort agents.

Table 2. Annual Antibiotic Consumption According to WHO AWaRe Classification

AWaRe Category	DDD/100 bed-days	Percentage (%)
Access	153.1	20.9
Watch	563.8	77.0
Reserve	15.4	2.1
Total	732.3	100

Chi-square p-value <0.001

Third-generation cephalosporins constituted the largest proportion of antibiotic utilization, accounting for more than half of total antimicrobial consumption (54.1%) (Table 3). Penicillin plus β-lactamase inhibitor combinations and aminoglycosides were the next most frequently utilized classes. Carbapenem consumption

accounted for 10.0%, indicating considerable use of broad-spectrum agents in critically ill patients.

Table 3. Annual Antimicrobial Consumption by Antibiotic Class

Antibiotic Class	DDD/100 bed-days	Share (%)
3rd-generation Cephalosporins	396.4	54.1
Penicillin + β-lactamase inhibitor	117.8	16.1
Aminoglycosides	97.1	13.3
Carbapenems	73.4	10.0
Oxazolidinones	15.4	2.1
Glycopeptides	11.9	1.6
Lincosamides	8.8	1.2
Penicillins	4.5	0.6
Fluoroquinolones	4.3	0.6
2nd-generation Cephalosporins	2.1	0.3
Macrolides	0.7	0.1

Chi-square p-value <0.001

Ceftriaxone emerged as the most frequently utilized antibiotic, contributing 299.9 DDD/100 bed-days, which was substantially higher than any other antimicrobial agent (Table 4). Amikacin represented the most commonly used Access antibiotic, while Piperacillin–Tazobactam, Meropenem, and Cefoperazone–Sulbactam collectively reflected extensive use of broad-spectrum Watch category agents. Linezolid was the only Reserve category antibiotic among the top ten consumed agents.

Table 4. Top Ten Individual Antibiotics by Annual Consumption

Antibiotic	AWaRe Category	DDD/100 bed-days
Ceftriaxone	Watch	299.9
Amikacin	Access	87.6
Piperacillin–Tazobactam	Watch	75.1
Meropenem	Watch	73.4
Cefoperazone–Sulbactam	Watch	71.0
Amoxycillin–Clavulanic Acid	Access	42.7
Cefotaxime	Watch	25.5
Linezolid	Reserve	15.4
Vancomycin	Watch	11.9
Gentamicin	Access	9.5

Chi-square p-value <0.001

Figures

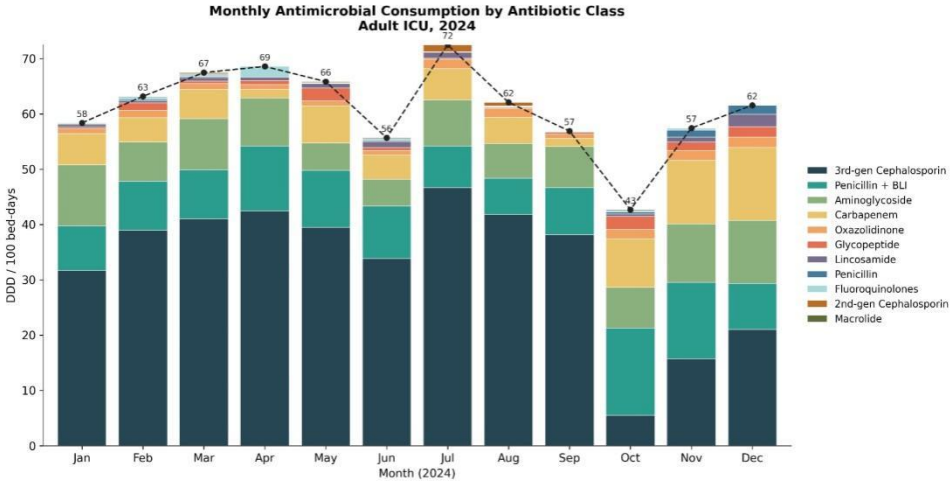

Figure 1. Monthly Antimicrobial Consumption by Antibiotic Class in Adult ICU, 2024

Source: Generated from antibiotic consumption data collected from the Central Pharmacy, Government General Hospital, Guntur, January–December 2024.

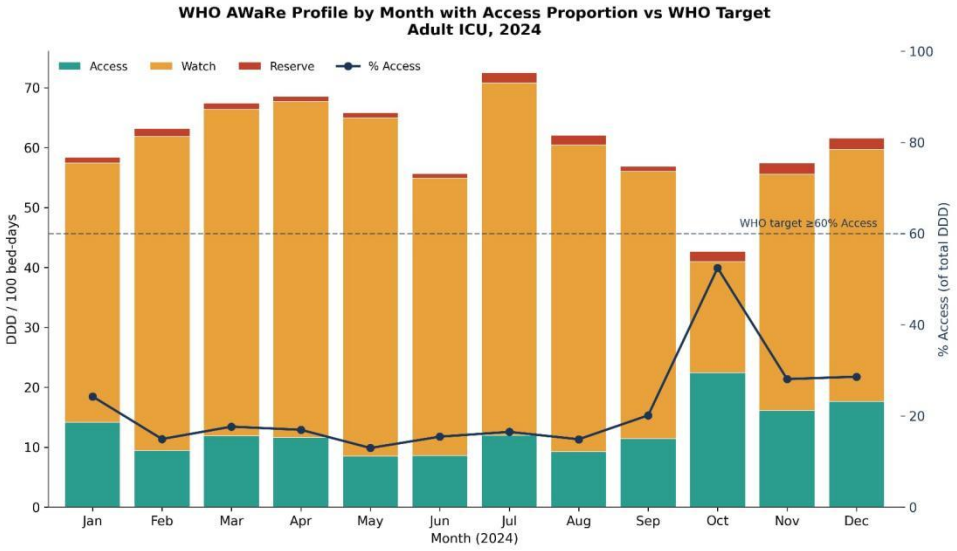

Figure 2. WHO AWaRe Profile by Month with Access Proportion Versus WHO Target

Source: Generated from monthly AWaRe-classified antimicrobial consumption data using WHO ATC/DDD methodology.

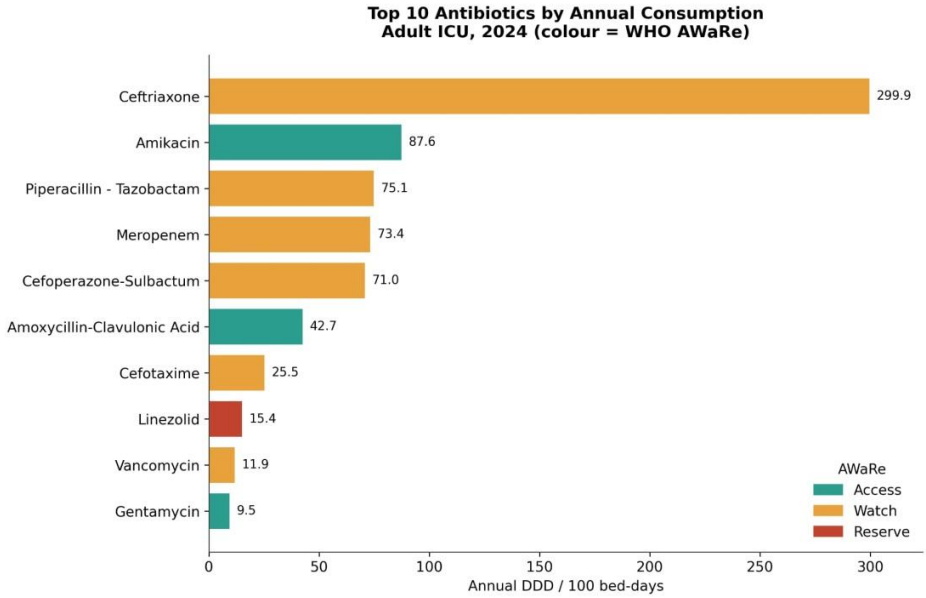

Figure 3. Top Ten Antibiotics by Annual Consumption in Adult ICU

Source: Generated from annual antimicrobial consumption analysis expressed as DDD/100 bed-days.

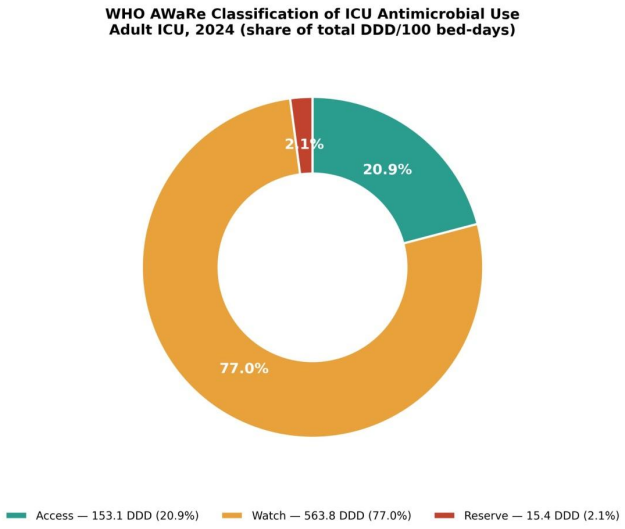

Figure 4. WHO AWaRe Classification of ICU Antimicrobial Use

Source: Generated from annual AWaRe-category antibiotic utilization data.

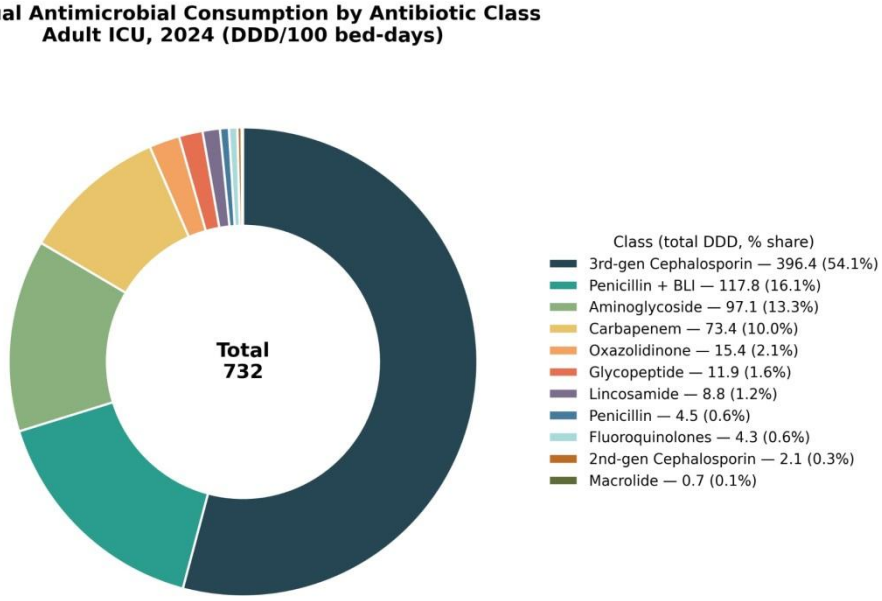

Figure 5. Annual Antimicrobial Consumption by Antibiotic Class

Source: Generated from annual antibiotic class-wise consumption data using WHO ATC/DDD methodology.

Discussion

Antimicrobial stewardship has become an essential component of healthcare systems worldwide because inappropriate antibiotic use is a major contributor to antimicrobial resistance (AMR). Intensive care units are recognized as high-risk environments for the emergence and spread of resistant pathogens due to extensive antibiotic exposure, invasive procedures, prolonged hospitalization, and the severity of underlying illnesses [11]. The present study assessed antibiotic consumption patterns among adult ICU patients using the WHO AWaRe classification and DDD/100 bed-days methodology and provides important insights into prescribing practices at a tertiary care teaching hospital.

The total annual antimicrobial consumption observed in the present study was 732.3 DDD/100 bed-days. Similar studies conducted in tertiary care hospitals have reported high antibiotic utilization rates in ICUs, reflecting the substantial burden of severe infections and empirical antibiotic prescribing among critically ill patients [12]. The monthly variation in antimicrobial consumption, ranging from 42.8 to 72.4 DDD/100 bed-days, likely reflects seasonal fluctuations in infectious diseases, differences in patient acuity, and variations in ICU occupancy.

A major finding of this study was the predominance of Watch category antibiotics, which accounted for 77.0% of total antimicrobial consumption. This observation is consistent with reports from several low- and middle-income countries where third-generation cephalosporins and broad-spectrum β-lactam agents remain the cornerstone of empirical therapy [13]. The WHO recommends that Access antibiotics should constitute at least 60% of total antibiotic use; however, Access antibiotics accounted for only 20.9% of antibiotic consumption in the present study. This substantial deviation from WHO targets suggests opportunities for improving antimicrobial stewardship and promoting more rational prescribing practices [5,14].

The low utilization of Access antibiotics may be attributed to the critically ill nature of ICU patients, where physicians frequently prefer broad-spectrum empirical therapy because of concerns regarding multidrug-resistant pathogens. Nevertheless, prolonged dependence on Watch category agents may accelerate the development of antimicrobial resistance and limit future therapeutic options [15].

Among AWaRe categories, Reserve antibiotics represented only 2.1% of total antimicrobial consumption. This finding is encouraging because Reserve agents are intended for confirmed or suspected infections caused by multidrug-resistant organisms and should remain restricted to preserve their effectiveness [16]. The limited use of Linezolid, which represented the primary Reserve antibiotic consumed during the study period, suggests a degree of adherence to antimicrobial stewardship principles.

Class-wise analysis demonstrated that third-generation cephalosporins accounted for 54.1% of total antibiotic utilization. This observation is largely attributable to the overwhelming use of Ceftriaxone, which alone contributed 299.9 DDD/100 bed-days. Similar dominance of Ceftriaxone has been reported in several Indian and international studies because of its broad antimicrobial spectrum, favorable safety profile, and widespread

availability [17]. However, excessive reliance on third-generation cephalosporins is associated with increasing rates of extended-spectrum β-lactamase (ESBL)-producing organisms and should be carefully monitored.
Penicillin plus β-lactamase inhibitor combinations represented the second most commonly used antibiotic class, accounting for 16.1% of total consumption. Piperacillin–Tazobactam was among the most frequently prescribed antibiotics and reflects its established role in empirical treatment of severe nosocomial infections. Carbapenems constituted 10.0% of total antibiotic utilization, indicating substantial use of last-line broad-spectrum therapy. Increased carbapenem consumption has been recognized as a predictor of carbapenem-resistant Enterobacterales emergence and therefore requires continuous surveillance [18].
Among individual antibiotics, Amikacin emerged as the most commonly utilized Access category agent. Aminoglycosides remain valuable therapeutic options because of their efficacy against Gram-negative pathogens and comparatively lower propensity for inducing resistance compared with broad-spectrum cephalosporins [19,20]. Encouraging greater use of appropriate Access antibiotics such as Amikacin and Amoxycillin–Clavulanic acid may help improve compliance with WHO stewardship targets.
The study has several strengths, including year-long surveillance, standardized DDD methodology, and utilization of the WHO AWaRe framework. Nevertheless, certain limitations should be acknowledged. The study evaluated antibiotic consumption rather than prescribing appropriateness, clinical outcomes, microbiological patterns, or resistance profiles. Patient-level variables such as diagnosis, severity scores, duration of therapy, and mortality were not assessed. Future studies integrating antibiotic utilization data with microbiological surveillance and clinical outcomes would provide a more comprehensive evaluation of antimicrobial stewardship performance [21-24].
Overall, the findings demonstrate a substantial dependence on Watch category antibiotics and a marked shortfall in Access antibiotic utilization compared with WHO recommendations. These observations underscore the need for strengthened stewardship interventions, regular prescription audits, implementation of antibiotic guidelines, and continuous education of healthcare professionals. Optimizing antibiotic use in ICU settings is essential to preserve antimicrobial effectiveness and combat the growing threat of AMR [20].

Conclusion

This study demonstrated that antibiotic consumption in adult ICUs was predominantly driven by Watch category antibiotics, which accounted for more than three-fourths of total antimicrobial utilization. Access antibiotic use remained substantially below the WHO-recommended target of 60%, while Reserve antibiotic consumption remained low. Ceftriaxone was the most frequently utilized antimicrobial agent, and third-generation cephalosporins represented the dominant antibiotic class. These findings highlight the need for robust antimicrobial stewardship programs aimed at increasing Access antibiotic utilization, reducing unnecessary broad-spectrum antibiotic exposure, and promoting rational prescribing practices to mitigate antimicrobial resistance.

References

1. Murray CJL, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019. Lancet. 2022;399(10325):629-655.
2. Laxminarayan R, Sridhar D, Blaser M, Wang M, Woolhouse M. Achieving global targets for antimicrobial resistance. Science. 2016;353(6302):874-875.
3. Vincent JL. Nosocomial infections in adult intensive-care units. Lancet. 2003;361(9374):2068-2077.
4. Kollef MH, Sherman G, Ward S, Fraser VJ. Inadequate antimicrobial treatment of infections. Chest. 1999;115(2):462-474.
5. World Health Organization. The WHO AWaRe Antibiotic Book. Geneva: WHO; 2022.
6. Hsia Y, Sharland M, Jackson C, Wong ICK, Magrini N. Consumption of WHO AWaRe antibiotics. Lancet Infect Dis. 2019;19(3):245-247.
7. WHO Collaborating Centre for Drug Statistics Methodology. Guidelines for ATC Classification and DDD Assignment 2024.
8. Hutchinson JM, Patrick DM, Marra F, Ng H, Bowie WR, Heule L, et al. Measurement of antibiotic consumption. J Antimicrob Chemother. 2004;53(2):159-167.
9. Klein EY, Van Boeckel TP, Martinez EM, Pant S, Gandra S, Levin SA, et al. Global increase in antibiotic consumption. Proc Natl Acad Sci USA. 2018;115:E3463-E3470.
10. Sulis G, Adam P, Nafade V, Gore G, Daniels B, Daftary A, et al. Antibiotic prescription practices in LMICs. PLoS Med. 2020;17:e1003139.
11. Bassetti M, Righi E, Carnelutti A. Bloodstream infections in the Intensive Care Unit. Virulence. 2016 Apr 2;7(3):267-79.
12. Versporten A, Zarb P, Caniaux I, Gros MF, Drapier N, Miller M, Jarlier V, Nathwani D, Goossens H;

Global-PPS network. Antimicrobial consumption and resistance in adult hospital inpatients in 53 countries: results of an internet-based global point prevalence survey. Lancet Glob Health. 2018 Jun;6(6):e619-e629. doi: 10.1016/S2214-109X(18)30186-4. Epub 2018 Apr 23. Erratum in: Lancet Glob Health. 2018 Sep;6(9):e968.
13. Pauwels I, Versporten A, Drapier N, Vlieghe E, Goossens H. Hospital antibiotic prescribing patterns. Clin Microbiol Infect. 2021;27(4):529-535.
14. Sharland M, Gandra S, Huttner B, Moja L, Pulcini C, Zeng M, et al. Encouraging AWaRe stewardship globally. Lancet Infect Dis. 2022;22:e11-e19.
15. Bell BG, Schellevis F, Stobberingh E, Goossens H, Pringle M. Consequences of antibiotic misuse. Int J Antimicrob Agents. 2014;44(3):203-210.
16. World Health Organization. WHO Model List of Essential Medicines, 24th List. Geneva: WHO; 2025.
17. Versporten A, Bielicki J, Drapier N, Sharland M, Goossens H; ARPEC project group. The Worldwide Antibiotic Resistance and Prescribing in European Children (ARPEC) point prevalence survey: developing hospital-quality indicators of antibiotic prescribing for children. J Antimicrob Chemother. 2016 Apr;71(4):1106-17. doi: 10.1093/jac/dkv418. Epub 2016 Jan 8. PMID: 26747104.
18. van Duin D, Doi Y. Carbapenem-resistant Enterobacteriaceae. Virulence. 2017;8(4):460-469.
19. Krause KM, Serio AW, Kane TR, Connolly LE. Aminoglycosides: mechanisms and stewardship. Cold Spring Harb Perspect Med. 2016;6:a027029.
20. Dyar OJ, Huttner B, Schouten J, Pulcini C; ESGAP (ESCMID Study Group for Antimicrobial stewardshiP). What is antimicrobial stewardship? Clin Microbiol Infect. 2017 Nov;23(11):793-798.
21. Kaur GP, Goyal JD, Movva JB, Sanda S, Aravinth R, Syed AK, et al. Impact of rapid response teams on patient outcomes in emergency departments: a multicenter study. J Cardiovasc Dis Res. 2023;14(6):2952-2958.
22. Balu PRS, Syed AK, Kotian T, Padala HSS, Gupta S, Tiwari R, et al. Efficacy of different triage protocols in reducing waiting times in emergency settings: a randomized controlled trial. J Pharm Bioallied Sci. 2025.
23. Penmathsa VNB, Siddiq Ali MM, Jasmine J, Heena HD, Rahul RT, Syed AK. Heat-related illnesses and emergency department visits in rural areas: a retrospective analysis. J Contemp Clin Pract. 2022;8(2):53-58.
24. Srilatha T, Kumar PV, Korapati A, Syed AK. Pattern of anemia and red cell indices in adult patients attending a tertiary care hospital: a retrospective laboratory-based study. Int J Med Public Health. 2026;16(1):1728-1732.