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Original Research Article

A Hospital-Based Analysis of Antimicrobial Utilization in Infectious Disease Management

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Abstract:

Introduction: Infectious diseases are a major global health concern, and antimicrobials are critical in managing these conditions, particularly in hospital settings. However, the widespread, often unregulated use of these drugs has led to a rise in antimicrobial resistance (AMR), threatening their efficacy. This study focuses on understanding antimicrobial utilization patterns in hospitalized patients to optimize therapy and reduce AMR risk.

Materials and Methods: This prospective, observational study was conducted over one year at a tertiary care hospital in Western Gujarat. It included adult patients with infectious diseases who received antimicrobial treatment. Data were collected through patient records, covering demographics, diagnosis, and antimicrobial therapy specifics. Antimicrobial use was analyzed using the WHO's ATC classification and defined daily doses (DDD), with results statistically assessed through SPSS software.

Results: Our study of 108 hospitalized patients revealed a nearly balanced gender distribution, with the majority in the 61–90 age range and a mean age of 56.8 years. Respiratory and urinary tract infections were the most common diagnoses, and diabetes mellitus was the leading comorbidity. The average hospital stay was 8.1 days, with most stays between 6-10 days. The average number of drugs per encounter was 7.31, all prescribed generically and sourced from the hospital formulary, with 80.95% of antibiotics administered via injection. Penicillins were the most frequently prescribed antimicrobial class, followed by cephalosporins, with tazobactam + piperacillin and ceftriaxone as prominent choices. A comparison of defined daily doses (DDD) and prescribed daily doses (PDD) for commonly used antimicrobials showed general adherence to WHO dosing guidelines, although amoxicillin + clavulanic acid and piperacillin + tazobactam were prescribed at slightly higher doses, likely tailored to specific patient needs.

Conclusion: Our study highlights the prevalent use of broad-spectrum antimicrobials in infectious disease management, with overall adherence to WHO dosing standards. Tailored dosing practices for specific cases emphasize the need for continued antimicrobial stewardship to optimize treatment outcomes and minimize resistance.

Keywords: Antimicrobial Utilization, Infectious Disease Management, Antimicrobial Resistance, Pharmacovigilance.

Introduction

Infectious diseases remain a significant cause of morbidity and mortality worldwide, with antimicrobial agents being central to their management. [1] In hospitals, where the concentration of infectious pathogens is often high and the patient population vulnerable, antimicrobial drugs play an essential role in treating infections and preventing complications. [2] However, the widespread and often unregulated use of antimicrobials has led to the development of antimicrobial resistance (AMR), a global public health threat that jeopardizes the effectiveness of these critical drugs. [3] Understanding the utilization patterns of antimicrobial agents in hospitalized patients with infectious diseases is crucial for optimizing therapy, enhancing treatment outcomes, and minimizing the risk of resistance development. [4]

Drug utilization studies, especially in hospital settings, provide valuable insights into prescribing trends and patterns, enabling the identification of potential areas for improvement in clinical practice. [5] Such studies are instrumental in evaluating adherence to treatment guidelines, determining the

appropriateness of prescribed therapies, and assessing the use of broad-spectrum versus narrow-spectrum antimicrobials. [6] With the rise of antimicrobial resistance, hospitals and healthcare systems are increasingly under pressure to ensure that antimicrobial prescriptions align with evidence-based guidelines and that drug use is rational and effective. [7] This study, therefore, aims to provide a detailed analysis of antimicrobial utilization patterns among hospitalized patients with infectious diseases, with a focus on identifying factors influencing drug selection and use. By identifying these patterns and practices, the findings from this study will contribute to developing targeted interventions, fostering antimicrobial stewardship, and ultimately enhancing patient outcomes in infectious disease management.

Material and Methods

This prospective, observational study aimed to analyze the utilization patterns of antimicrobial agents in patients hospitalized with infectious diseases. Conducted over a one-year period from January 2023 to December 2023, the study was based in the Department of Internal Medicine at a tertiary care center in Western Gujarat.

The study took place in a tertiary care teaching hospital that manages a high volume of complex infectious disease cases. The sample size was calculated using the Raosoft calculator, considering a 5% margin of error, 95% confidence interval, and 50% response distribution, resulting in a target sample size of 108. The study included adult patients aged 18 years and older who were diagnosed with infectious diseases and received at least one antimicrobial agent (AMA) during hospitalization. Exclusion criteria included patients undergoing long-term AMA therapy, those transferred from other departments, ICU admissions, patients diagnosed with COVID-19, those with incomplete medical records, and pregnant or lactating individuals.

Data were collected daily by the study investigator, who attended ward rounds and reviewed patient case records to identify eligible participants. Informed consent was obtained from all participants before enrollment. A structured data collection form was used to record information from electronic medical records, covering demographics (age, gender), clinical diagnosis, microbiological test results, and antimicrobial therapy specifics such as drug name (brand and generic), dose, route, and treatment duration. Continuous data verification ensured data completeness and accuracy.

Antimicrobials were categorized according to the Anatomical Therapeutic Chemical (ATC) Classification System of the World Health Organization (WHO). To quantify antimicrobial usage, defined daily doses (DDD) per 100 bed days were calculated for each drug by dividing the amount prescribed by the WHO DDD standard, allowing for a standardized measure of drug consumption. Additionally, prescribed daily doses (PDD) were determined by calculating the DDD multiplied by the ratio of the number of DDDs to total treatment days, thus assessing prescription adherence to WHO norms.

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) software, version 26 (IBM, SPSS Inc.). Descriptive statistics summarized patient demographics and drug utilization patterns, while logistic regression analysis assessed the influence of variables like age, diagnosis, and number of AMAs on prescribing trends. Results were presented as odds ratios (OR) with 95% confidence intervals (CI), with statistical significance set at $P < 0.05$.

Results

In our study of 108 hospitalized patients, the gender distribution was nearly balanced, with 55.56% male (n=60) and 44.44% female (n=48). The majority of patients (41.67%) were in the 61–90 age group, followed by 31–60 years (37.04%). The mean age was 56.8 ± 22.3 years. Co-morbidities were common, with 36.11% of patients having 1–2 comorbid conditions, while 42.59% had none. Hospital stays predominantly ranged from 6–10 days (57.41%), with an average length of stay of 8.1 ± 3.1 days. (Table1)

Table 1: Sociodemographic and Clinical Characteristics

Characteristics	Frequency (n=108)	Percentage (%)
Age-wise Distribution		
0–30	18	16.67
31–60	40	37.04
61–90	45	41.67
91 and above	5	4.63
Co-morbidities		
Nil	46	42.59
1–2	39	36.11
3–4	19	17.59

≥5	4	3.70
Length of Hospital Stay		
1–5 days	25	23.15
6–10 days	62	57.41
11–15 days	15	13.89
≥16 days	6	5.56

In our study, the most common diagnoses among hospitalized patients were respiratory tract infections, accounting for 34.26% (n=37), followed closely by urinary tract infections at 33.33% (n=36). Sepsis was observed in 14.81% (n=16) of cases, while gastroenteritis constituted 7.41% (n=8). Other less frequent diagnoses, comprising 10.19% (n=11), included conditions like pancreatitis, pyelonephritis, pelvic inflammatory disease, meningitis, enteric fever, diarrhea, and food poisoning. (Figure 1)

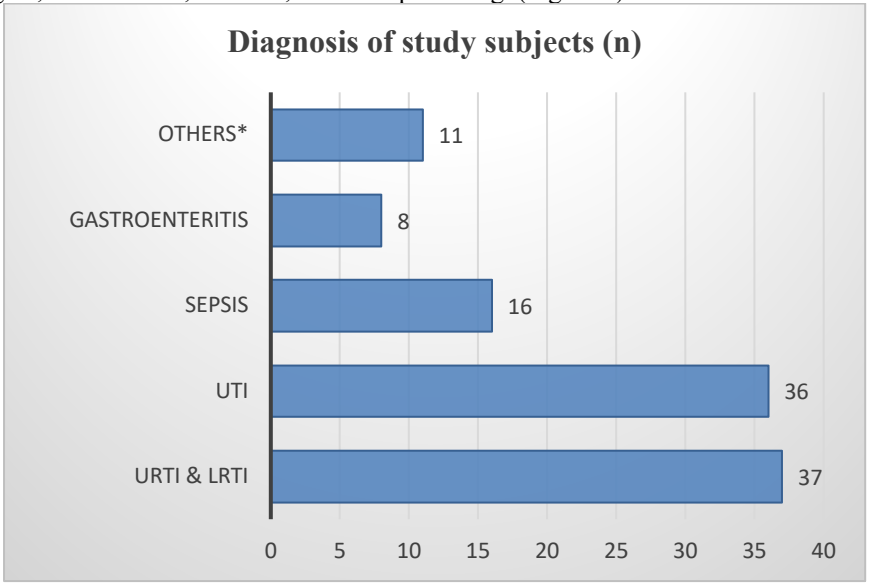

Figure 1: Diagnosis of study subjects (n)

In our study of 108 patients, diabetes mellitus was the most prevalent comorbidity, affecting 22.22% (n=24) of the study population, followed by hypertension at 18.52% (n=20). Anemia was present in 7.41% (n=8) of patients, while stroke and other conditions like dyslipidemia and ischemic heart disease each accounted for smaller proportions, ranging from 2.78% to 5.56%. Less common comorbidities included Parkinson's disease and chronic kidney disease, both at 2.78% (n=3). (Table 2).

Table 2: Distribution of Comorbidities

Comorbidity	Frequency (n)	Percentage of Total (n=108)
Diabetes Mellitus	24	22.22
Hypertension	20	18.52
Stroke	6	5.56
Anemia	8	7.41
Dyslipidemia	5	4.63
Parkinson Disease	3	2.78
Ischemic Heart Disease	5	4.63
Chronic Kidney Disease	3	2.78
Asthma	4	3.70
Others	8	7.41

In our study, the average number of drugs per encounter was 7.31, with all drugs prescribed by their generic names and 100% sourced from the hospital's formulary list. Approximately 80.95% of antibiotic encounters included injection forms, with an average of 1.94 antibiotics prescribed per prescription. (Table 3)

Table 3: World Health Organization Drug Prescribing Indicators of Antimicrobial Agents

Prescribing Indicators	Calculations	Values (%)
Average number of drugs per encounter	790/108	7.31
Percentage of drugs prescribed by generic name	790	100
Number of antibiotics prescribed per prescription	210/108	1.94
Percentage of encounters with injection antibiotics prescribed	170/210	80.95
Percentage of drugs from the formulary list of the study setting	790/790	100
Percentage of patients who received one antibiotic per prescription	45/108	41.67
Percentage of patients who received two or more antibiotics per prescription	63/108	58.33

In our study, penicillins were the most frequently prescribed class of antimicrobial agents, accounting for 26.50% of prescriptions, with tazobactam + piperacillin as the most common combination. Cephalosporins followed closely at 21.00%, predominantly ceftriaxone. (Table 4)

Table 4. Frequencies of the Antimicrobial Agents Prescribed

Class of AMAs	n=200, n (%)
Penicillins	53 (26.50)
Tazobactam + piperacillin	42
Amoxicillin + clavulanic acid	11
Cephalosporins	42 (21.00)
Ceftriaxone	30
Ceftazidime	5
Cefuroxime	7
Fluoroquinolones	34 (17.00)
Levofloxacin	26
Ciprofloxacin	8
Carbapenems	30 (15.00)
Meropenem	27
Ertapenem	3
Tetracyclines	12 (6.00)
Doxycycline	10
Tigecycline	2
Glycopeptides	8 (4.00)
Vancomycin	8
Nitroimidazoles	9 (4.50)
Metronidazole	9
Macrolides	3 (1.50)
Azithromycin	1
Clarithromycin	2
Aminoglycosides	1 (0.50)
Gentamicin	1
Others (clindamycin [n=1], linezolid [n=1])	2 (1.00)

In our study, a comparison of the defined daily doses (DDD) and prescribed daily doses (PDD) of commonly used antimicrobial agents revealed general adherence to standard dosing practices. Metronidazole, ceftriaxone, and levofloxacin had PDD values closely aligned with the World Health Organization (WHO) DDD recommendations, indicating consistent prescribing practices. However, certain agents like amoxicillin + clavulanic acid and piperacillin + tazobactam were prescribed at slightly higher doses (PDD 3.6 g and 13.5 g, respectively) compared to their WHO DDD values, reflecting tailored dosing in specific patient cases. (Table 5)

Table 5. Comparison of Defined Daily Doses and Prescribed Daily Doses of Antimicrobial Agents Prescribed

Antimicrobial agents	ATC CODE	WHO DDD g	No. of patients	PDD g
Metronidazole	J01XD01	1.5	308	1.5
Ceftriaxone	J01DD04	2	283	1.9
Amoxicillin+clavulanic acid	J01CR02	3	173	3.6

Levofloxacin	J01MA12	0.5	116	0.5
Cefotaxime	J01DD01	4	83	2
Meropenem	J01DH02	2	82	2
Ciprofloxacin	J01MA02	0.5	60	1
Piperacillin + Tazobactam	J01CR05	14	58	13.5
Linezolid	J01XX08	1.2	38	1.2
Amikacin	J01GB06	1	36	1
Artisunate	P01BE03	0.28	37	0.25
Azithromycin	J01FA10	0.5	18	1
Gentamycin	J01GB03	0.24	18	0.42
Clindamycin	J01FF01	1.8	17	1.16
Oseltamivir	J05AH02	0.15	10	0.3
Cefoperazone + sulbactam	J01DD62	4	9	3.2

Discussion

In our study of 108 patients, we observed a balanced gender distribution with 55.56% male and 44.44% female patients, and the majority were within the 61–90 age range, with a mean age of 56.8 years. Comparatively, studies such as that by Saxena et al. [8] in an ICU setting at a tertiary hospital showed a predominance of male patients and a slightly lower mean age, emphasizing that demographics can vary based on hospital setting and geographical location. Our co-morbidity distribution showed that over a third of patients had 1–2 co-morbidities, which aligns with findings by Satapathy et al. [9], who also highlighted common co-morbidities like hypertension and diabetes as prevalent conditions influencing antimicrobial prescriptions.

Our study's mean hospital stay was 8.1 days, with the majority staying between 6–10 days. Similar patterns were found in studies by Adhikari et al. [10] and Nawa et al. [11], where average ICU stays varied around a similar duration depending on the severity of cases and antimicrobial resistance factors. This finding underscores the importance of antimicrobial stewardship in reducing hospitalization durations, as prolonged stays often correlate with increased antibiotic usage and the potential for resistance.

In our study of 108 patients, diabetes mellitus emerged as the most prevalent comorbidity, affecting 22.22% of the cohort, followed closely by hypertension at 18.52%. This high prevalence of metabolic conditions is consistent with findings by Panigrahi et al. [12], who also observed diabetes and hypertension as dominant comorbidities in a tertiary care hospital in Western Odisha, where these conditions significantly influenced treatment plans and antimicrobial usage due to associated infection risks. Similarly, Gülmez et al.'s [13] research highlighted diabetes and hypertension as primary comorbidities among patients, emphasizing the heightened vulnerability of these individuals to infections and the necessity for targeted antimicrobial strategies.

Other conditions in our study, such as anemia (7.41%), stroke, dyslipidemia, and ischemic heart disease (ranging from 2.78% to 5.56%), are in line with trends identified by Benjamin et al. [14], who reported a significant presence of cardiovascular and metabolic diseases among ICU patients, which complicates patient outcomes and often necessitates the use of broad-spectrum antibiotics due to prolonged hospital stays and increased susceptibility to secondary infections. Furthermore, studies by Adhikari et al. [10] underscored the critical role of coexisting medical conditions, such as chronic kidney disease (CKD), in shaping antimicrobial utilization patterns, as CKD patients require cautious antibiotic dosing due to altered pharmacokinetics and a higher risk of adverse reactions.

In our study, the average number of drugs per encounter was 7.31, aligning with findings by Ogunleye et al. [15], who reported similar results in a tertiary care hospital, reflecting the high medication load needed to manage complex cases. The use of generic names for all prescriptions, reaching 100% in our study, is consistent with the findings by Patra et al. [16], who emphasized that generic prescribing aligns with WHO guidelines and enhances cost-effectiveness in healthcare settings. Our study's average of 1.94 antibiotics per prescription closely matches results from Gülmez et al. [13], where approximately two antibiotics per prescription were commonly used, reflecting the need for broad-spectrum coverage and combination therapy in hospitalized patients. Furthermore, the high percentage (80.95%) of encounters involving injectable antibiotics in our study is consistent with Satapathy et al. [9], who also observed a predominance of injection-based prescriptions for critical cases due to their faster action and greater bioavailability. Lastly, our finding that 58.33% of patients received two or more antibiotics aligns with observations by Nawa et al. [11] which

highlighted a similar trend in ICU settings to use multiple antibiotics to cover a broad range of pathogens and combat resistance effectively.

In our study, penicillins were the most frequently prescribed class of antimicrobial agents, accounting for 26.5% of prescriptions, with tazobactam + piperacillin being the most common combination. This aligns with findings by Ogunleye et al. [15], where penicillins were also highly prescribed in hospital settings due to their broad-spectrum efficacy and cost-effectiveness, making them a staple in antimicrobial therapy. Cephalosporins, the second most prescribed class at 21%, included ceftriaxone as the predominant choice, mirroring results by Satapathy et al. [9] who noted a similar reliance on ceftriaxone for its potent action against a broad range of pathogens. The substantial usage of fluoroquinolones in our study (17%), with levofloxacin as the primary agent, also reflects trends observed in the work by Patra et al. [16], who highlighted levofloxacin's effectiveness in respiratory and urinary tract infections, which are common among hospitalized patients.

Carbapenems were also widely used in our study, constituting 15% of the total prescriptions, with meropenem as the most prescribed drug within this class. This finding is consistent with Gülmez et al. [13], who reported high usage of meropenem in intensive care settings, attributing its popularity to its broad-spectrum activity against resistant pathogens. Similarly, the prescription of glycopeptides, particularly vancomycin (4%), aligns with the trends noted by Nawa et al. [11], where vancomycin was frequently used in response to resistant Gram-positive infections. Other antimicrobials, such as nitroimidazoles (4.5%), primarily metronidazole, and tetracyclines (6%) like doxycycline, were less frequently prescribed but still significant in specific infection cases. Overall, this distribution highlights a pattern consistent with other studies that reflect the continued reliance on broad-spectrum antibiotics, with adjustments made for resistance management and targeted therapy in specialized cases.

In our study, the comparison between the WHO-defined daily doses (DDD) and the prescribed daily doses (PDD) of various antimicrobial agents revealed several patterns. For agents like metronidazole, levofloxacin, linezolid, and amikacin, the PDD matched the WHO DDD, suggesting consistency in dosing practices with international guidelines. However, certain antimicrobials, including amoxicillin + clavulanic acid and piperacillin + tazobactam, had higher PDD values (3.6g and 13.5g, respectively) compared to their WHO DDD. This increase reflects a tailored approach to dosing, possibly due to severe infection cases requiring intensified therapy. Similar trends have been observed in studies by Ogunleye et al. [15] and Patra et al. [16], who also noted deviations in dosing for critical cases, particularly with beta-lactams and combination therapies. For ceftriaxone, our study's PDD was slightly above the WHO DDD, aligning with findings by Satapathy et al. [9], where clinicians favored higher doses for resistant bacterial infections. This comparative analysis suggests that while adherence to WHO standards is generally maintained, necessary adjustments are often made to accommodate patient-specific needs and severity of infections.

The primary limitations of our study include its single-center design, which may limit the generalizability of findings to other healthcare settings with different patient demographics and prescribing practices. Additionally, while we analyzed the frequency and dosing of antimicrobial agents, we did not assess patient outcomes in relation to antimicrobial use, which could provide deeper insights into the effectiveness of these treatments. The study also relied on prescription data without considering patient adherence or potential variations in clinical severity, which could influence antimicrobial selection and dosing adjustments. Lastly, the absence of long-term follow-up limits our ability to evaluate the impact of prescribed regimens on resistance patterns over time.

Conclusion

In conclusion, our study reflects a prescribing pattern that aligns closely with WHO recommendations and practices observed in similar hospital settings, demonstrating a balanced approach to antimicrobial use. The reliance on broad-spectrum antibiotics, particularly penicillins and cephalosporins, underscores their effectiveness and cost-efficiency, while the tailored use of higher prescribed doses in severe cases highlights clinicians' adaptability in managing complex infections. The observed adherence to generic prescribing and formulary guidelines supports cost-effective healthcare delivery, while the consistent use of injectables indicates a focus on achieving rapid therapeutic outcomes.

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