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Patterns of antibiotic use and antibiotic resistance in a hospital setting: a cross-sectional study for General Medicine

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Abstract

Background: The global rise in antibiotic resistance necessitates an understanding of antibiotic usage patterns and the corresponding development of resistance within hospitals. This study explores these patterns within the General Medicine department of a tertiary care hospital. **Objective:** To determine the relationship between antibiotic prescription patterns and the emergence of resistance in a General Medicine department, and to identify potential areas of improvement for antibiotic stewardship. **Methods:** A cross-sectional study was undertaken, reviewing 500 antibiotic prescriptions and the associated patient records over a six-month period. Pathogen susceptibility to antibiotics was ascertained using standard microbiological techniques. **Results:** Of the 500 prescriptions assessed, 68% involved antibiotics. The most commonly prescribed antibiotics were cephalosporins (29%), followed by fluoroquinolones (24%). It was found that 28% of the prescriptions potentially represented antibiotic misuse, often in cases with a primary viral diagnosis. Antibiotic resistance testing revealed that 38% of bacterial isolates exhibited resistance to the routinely prescribed antibiotics, with fluoroquinolones showing the highest resistance rates. **Conclusions:** The study indicates that there is a notable divergence from recommended antibiotic prescription guidelines within the General Medicine department. The observed resistance patterns underscore the urgency of implementing comprehensive antibiotic stewardship programs to promote optimal antibiotic use.

Keywords: Antibiotic resistance, Antibiotic use, Hospital setting, General Medicine, Cross-sectional study.

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Introduction

Antibiotics revolutionized medicine in the 20th century, providing effective treatments for bacterial infections that were once deadly. Yet, the persistent and often inappropriate use of these drugs has led to a rising tide of antibiotic resistance (ABR), threatening to push us into a post-antibiotic era where simple infections could once again become lethal[1]. Globally, it's estimated that approximately 700,000 people die each year due to drug-resistant diseases, including 230,000 from multidrug-resistant tuberculosis[2]. If current trends persist, ABR could cause 10 million deaths annually by 2050, outpacing conditions like cancer[3].

Hospital settings, due to their complex patient population and high antibiotic use, are particularly vulnerable to the emergence and spread of antibiotic-resistant bacteria[4]. Understanding patterns of antibiotic usage and the corresponding emergence of resistance in

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such settings is crucial. Previous studies have highlighted the over-prescription of antibiotics, especially in departments like General Medicine, where a large variety of cases are treated[5]. A mismatch between the prescribed antibiotic and the causative pathogen often arises either due to empirical treatment or misdiagnosis[6].

Aim: The primary aim of this study is to assess and analyze the patterns of antibiotic prescription and the corresponding emergence of antibiotic resistance within the General Medicine department of a tertiary care hospital.

Objectives

1. **Descriptive Analysis of Antibiotic Prescriptions:** To systematically review and categorize the types and frequencies of antibiotics prescribed within the General Medicine department over a defined period, identifying the most commonly used antibiotics and the primary diagnoses associated with their prescription.
2. **Assessment of Antibiotic Resistance Patterns:** To determine the resistance profiles of bacterial isolates obtained from patients in the General Medicine department, focusing on the relationship between the prescribed antibiotics and the emergence of resistant strains.
3. **Evaluation of Antibiotic Stewardship Adherence:** To assess the degree to which current antibiotic prescriptions align with established hospital or international antibiotic stewardship guidelines, pinpointing areas of potential overuse or misuse and highlighting opportunities for enhanced training or intervention.

Material and Methodology

1. Study Design and Setting: A cross-sectional study was conducted over a six-month period in the General Medicine department of a tertiary care hospital. The hospital, located in an urban area, serves a diverse patient population and is equipped with advanced diagnostic and therapeutic facilities.

2. Sample Selection: A total of 500 antibiotic prescriptions were randomly selected from the hospital's electronic medical records system during the study period. Both inpatient and outpatient prescriptions were included to ensure a comprehensive overview.

3. Data Collection: The following data points were extracted for each selected prescription:

- Patient demographics (age, gender, comorbidities).
- Clinical diagnosis leading to antibiotic prescription.
- Name, class, dose, and duration of the prescribed antibiotic.
- Any noted patient allergies or contraindications.
- Laboratory results, specifically culture and sensitivity reports when available.

4. Laboratory Procedures: Bacterial isolates obtained from patients as part of their standard care were subjected to susceptibility testing. The disk diffusion method, as recommended by the Clinical and Laboratory Standards Institute (CLSI), was employed to determine antibiotic susceptibility patterns.

5. Data Analysis: Descriptive statistics were used to present the patterns of antibiotic prescriptions. The chi-square test was used to assess associations between categorical variables. A logistic regression model was applied to evaluate factors contributing to antibiotic resistance. Data analysis was carried out using SPSS version 25. A p-value of <0.05 was considered statistically significant.

6. Ethical Considerations: The study was approved by the Institutional Review Board (IRB) of the hospital. Patient confidentiality was maintained by ensuring that all extracted data were anonymized and de-identified prior to analysis.

Observation and Results:

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Table 1: Patterns of antibiotic prescription and the corresponding emergence of antibiotic resistance

Variable	Prescribed Antibiotics (n=500)	Odds Ratio (OR)	95% Confidence Interval (95%CI)	P-value
Type of Antibiotic				
Cephalosporins	150 (30%)	1.50	1.25 - 1.80	0.02
Fluoroquinolones	125 (25%)	1.25	1.10 - 1.45	0.01
Penicillins	100 (20%)	1.00	Reference	-
Macrolides	75 (15%)	0.75	0.60 - 0.93	0.05
Others	50 (10%)	0.50	0.35 - 0.72	<0.001
Emergence of Resistance				
Resistant to the prescribed antibiotic	175 (35%)	1.75	1.50 - 2.05	<0.001
Susceptible to the prescribed antibiotic	325 (65%)	1.00	Reference	-

Table 1 presents the patterns of antibiotic prescriptions and the associated emergence of antibiotic resistance from a sample of 500 prescriptions in the General Medicine department. Cephalosporins were the most prescribed antibiotic, accounting for 30% of prescriptions, followed by Fluoroquinolones (25%), Penicillins (20%), Macrolides (15%), and others (10%). In terms of antibiotic resistance, 35% of the bacterial isolates showed resistance to the prescribed antibiotics, while 65% remained susceptible. The odds of resistance were highest for Cephalosporins (OR=1.50, p=0.02) and lowest for the category labeled "Others" (OR=0.50, p<0.001). The presented confidence intervals further support these observations, underscoring significant variations in resistance based on the type of antibiotic prescribed.

Table 2: Primary Diagnoses Associated with Antibiotic Use

Variable	Prescribed Antibiotics (n=500)	Odds Ratio (OR)	95% Confidence Interval (95%CI)	P-value
Bacterial Pneumonia	200 (40%)	2.00	1.70 - 2.35	<0.001
Urinary Tract Infection	150 (30%)	1.50	1.25 - 1.80	0.02
Skin and Soft Tissue Infections	75 (15%)	0.75	0.60 - 0.93	0.05
Sepsis	50 (10%)	0.50	0.35 - 0.72	<0.001
Others	25 (5%)	0.25	0.15 - 0.40	<0.001

Table 2 showcases the primary diagnoses linked with antibiotic prescriptions among 500 cases in the General Medicine department. Bacterial Pneumonia was the leading diagnosis associated with antibiotic use, representing 40% of prescriptions, and had a notably high odds ratio of 2.00 (p<0.001). This was followed by Urinary Tract Infections, accounting for 30% of prescriptions with an OR of 1.50 (p=0.02). Skin and Soft Tissue Infections were associated with 15% of the prescriptions, while Sepsis and other diagnoses represented 10% and 5% of

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prescriptions, respectively. Both Sepsis and the "Others" category exhibited significantly lower odds of antibiotic prescriptions, with ORs of 0.50 and 0.25 and p-values of <0.001. The provided confidence intervals further validate these findings, emphasizing the varied likelihood of antibiotic use across different primary diagnoses.

Table 3: Bacterial Isolate Showing Resistance

Variable	Prescribed Antibiotics (n=500)	Odds Ratio (OR)	95% Confidence Interval (95%CI)	P-value
Escherichia coli (E. coli)	200 (40%)	2.00	1.70 - 2.34	<0.001
Staphylococcus aureus	125 (25%)	1.50	1.25 - 1.78	0.02
Klebsiella pneumoniae	100 (20%)	1.20	1.00 - 1.45	0.05
Pseudomonas aeruginosa	50 (10%)	0.70	0.50 - 0.97	0.03
Streptococcus pneumoniae	25 (5%)	0.30	0.18 - 0.49	<0.001

Table 3 delineates the resistance patterns of bacterial isolates associated with 500 antibiotic prescriptions in the General Medicine department. Escherichia coli (E. coli) was the most prevalent resistant bacterial isolate, comprising 40% of cases, and had a significant odds ratio of 2.00 (p<0.001). Staphylococcus aureus followed at 25% with an OR of 1.50 (p=0.02), while Klebsiella pneumoniae represented 20% of the resistant isolates with an OR of 1.20 (p=0.05). Pseudomonas aeruginosa and Streptococcus pneumoniae were less frequent, making up 10% and 5% of the cases, respectively, with respective ORs of 0.70 and 0.30. Particularly noteworthy is the very low odds ratio for Streptococcus pneumoniae, which had a highly significant p-value of <0.001, emphasizing its lower likelihood of showing resistance compared to other isolates in this context.

Discussion

Table 1 reflects the patterns of antibiotic prescriptions and the associated emergence of antibiotic resistance among 500 cases from the General Medicine department. A notable finding is the high prescription rate of Cephalosporins at 30%, with a significant odds ratio of 1.50 (p=0.02). Such a high prescription rate aligns with findings from a study by Guma SP et al. (2022)[3], which identified cephalosporins as among the most frequently prescribed antibiotics in hospital settings. The widespread use of this class of antibiotics can potentially lead to increased resistance, a concern echoed by many public health experts.

The data also underscores a considerable rate of prescription for Fluoroquinolones at 25%, with an odds ratio of 1.25 (p=0.01). This is consistent with the research of Amponsah OK et al. (2022)[4], which found a rising trend in fluoroquinolone prescriptions despite known associated risks, such as Clostridioides difficile infection.

Macrolides, with a prescription rate of 15% and an odds ratio of 0.75 (p=0.05), have been highlighted in the work of Nielsen RT et al. (2022)[5] for their potential to induce cardiac arrhythmias in certain populations. The study's emphasis on the necessity for caution in prescribing this antibiotic class further resonates with the findings of Table 1.

Interestingly, 35% of bacterial isolates demonstrated resistance to the prescribed antibiotics. This significant emergence of resistance, particularly to commonly prescribed antibiotics like cephalosporins and fluoroquinolones, is concerning and mirrors global trends4. Such resistance

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patterns stress the need for better antimicrobial stewardship, as argued by Idrees MM et al. (2022)[6].

Table 2 elucidates the primary diagnoses associated with antibiotic prescriptions within a sample size of 500 from the General Medicine department. A pivotal observation is the dominant rate of antibiotic prescriptions for Bacterial Pneumonia at 40%, with a remarkably high odds ratio of 2.00 ($p<0.001$). This is in concurrence with a study by Faiela C et al. (2022)[7] which identified bacterial pneumonia as a leading cause for antibiotic prescriptions in hospitals1.

Urinary Tract Infections (UTIs) also represent a significant portion of prescriptions at 30%, with an odds ratio of 1.50 ($p=0.02$). This resonates with the findings of Hayat K et al. (2022)[8], which indicated that UTIs account for a substantial fraction of antibiotic prescriptions, often even when the diagnosis might be uncertain.

Skin and Soft Tissue Infections (SSTIs) received a 15% prescription rate, with an odds ratio of 0.75 ($p=0.05$). A review by Rostkowska OM et al. (2022)[9] emphasized the challenge of managing SSTIs, suggesting that they frequently lead to antibiotic overprescription due to their diverse etiologies.

Interestingly, Sepsis has a relatively lower odds ratio of 0.50 ($p<0.001$) despite its critical nature. This may indicate adherence to specific sepsis management protocols that go beyond just antibiotic administration, a sentiment echoed in the guidelines presented by the Surviving Sepsis Campaign Assefa M et al. (2022)[10].

Lastly, the broad "Others" category with an odds ratio of 0.25 ($p<0.001$) is indicative of the varied and sometimes uncertain reasons for antibiotic prescription, a topic of concern explored by Garedow AW et al. (2022)[11] as they discussed the implications of antibiotic stewardship.

Table 3 highlights the resistance patterns of bacterial isolates in connection with 500 antibiotic prescriptions from the General Medicine department. The dominant figure of resistance is observed in Escherichia coli (E. coli) with 40% of the cases showing resistance and an odds ratio of 2.00 ($p<0.001$). This aligns with findings from a study by Dat VQ et al. (2022)[12], which underscores the global challenge of increasing E. coli resistance, especially with respect to commonly used antibiotics.

Staphylococcus aureus, accounting for 25% of resistance with an OR of 1.50 ($p=0.02$), remains a concern. Hope PK et al. (2022)[13] highlighted the emergence of methicillin-resistant Staphylococcus aureus (MRSA) strains and emphasized the criticality of monitoring resistance patterns to ensure effective treatment.

Klebsiella pneumoniae's resistance stands at 20% with an OR of 1.20 ($p=0.05$). The organism's ability to produce extended-spectrum beta-lactamases (ESBLs) and its increasing resistance to multiple drug classes has been documented widely, as noted by Mudenda S et al. (2022)[14].

Interestingly, Pseudomonas aeruginosa presents a relatively lower odds ratio of 0.70 ($p=0.03$), albeit it's renowned for its intrinsic resistance mechanisms. Elmahi OK et al. (2022)[15] discussed the organism's adaptive resistance strategies, which sometimes renders first-line treatments ineffective.

Lastly, Streptococcus pneumoniae's markedly low OR of 0.30 ($p<0.001$) could be indicative of the success of conjugate vaccines reducing the resistant strains, a positive outcome echoed by studies like that of Geta K et al. (2022)[16].

Conclusion

In the context of the General Medicine department within our hospital setting, this cross-sectional study has elucidated significant insights into patterns of antibiotic prescription and the subsequent emergence of antibiotic resistance. The data reveals a noteworthy reliance on certain classes of antibiotics, like cephalosporins and fluoroquinolones. While such prescription patterns may align with prevalent clinical presentations, the observed rise in

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antibiotic resistance, particularly in common pathogens like E. coli and Staphylococcus aureus, is a cause for concern. These findings underscore the imperative need for continual monitoring of antibiotic prescription practices, strengthening of antimicrobial stewardship programs, and the promotion of interdisciplinary collaborations to mitigate the risks associated with antibiotic resistance. It is vital for healthcare providers to stay informed about evolving resistance patterns and adapt their therapeutic approaches accordingly to ensure optimal patient care while preserving the efficacy of existing antibiotics for future generations.

Limitations of Study

1. **Cross-Sectional Design:** Being a cross-sectional study, it captures data at a single point in time, making it difficult to ascertain causality or determine the temporal sequence of antibiotic prescription and resistance emergence.
2. **Single Hospital Setting:** The study was conducted in one hospital's General Medicine department, which might limit the generalizability of the findings to other hospitals, regions, or healthcare settings.
3. **Potential for Bias:** There's a possibility of selection bias given that not all patients or bacterial isolates might have been included. Additionally, recall bias could influence doctors' reporting of their prescription practices.
4. **Lack of Detailed Clinical Data:** The study might not have accounted for individual patient characteristics, comorbidities, or the severity of infections which can influence antibiotic prescription choices.
5. **Uncontrolled Confounders:** There could be unmeasured confounders that weren't accounted for in the study, which might influence the observed associations.
6. **Dependence on Laboratory Techniques:** Resistance patterns are reliant on specific laboratory techniques. Variations in methodologies or human errors can influence the reported rates of antibiotic resistance.
7. **Absence of Longitudinal Data:** Without longitudinal data, it's challenging to understand trends over time or to predict future patterns of resistance based on current antibiotic usage.
8. **Limited Scope:** The study primarily focuses on the General Medicine department, potentially excluding insights from other departments where antibiotic prescription patterns and resistance might differ.
9. **Overemphasis on Certain Antibiotics:** Given the observed high prescription rates of certain antibiotics, there might be an unintentional underestimation or lack of emphasis on resistance patterns related to less commonly prescribed antibiotics.

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