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Original Article

A Comparative Study on Assessment of Empiric Antibiotic Susceptibility Rates between Traditional and Syndromic Antibiogram

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ABSTRACT

Background: Antibiogram serves as a crucial tool for providing guidance in empiric therapy. Most of the hospitals rely on Traditional Antibiograms (TA) for prescribing antibiotics. But recognizing the importance of Syndromic Antibiograms (SA) and integrating it into clinical practice enhances the effectiveness of empiric antibiotic therapy. It is crucial for the Antimicrobial Stewardship Programs (AMSPs) to extend their approach beyond the TA. Purpose: This prospective study was aimed to compare the susceptibility rates between a traditional and syndromic antibiogram for the most common organisms. **Materials and Methods:** This study was conducted in a tertiary care hospital, Chennai for a period of 6 months. SA's were developed and compared with TA to analyze the antibiotic susceptibility of the most common pathogens associated with Urinary Tract Infection (UTI), Respiratory Tract Infection (RTI) and Blood Stream Infection (BSI). The collected data were analyzed using SPSS version 23. **Results:** A total of 400 bacterial isolates were examined. The three most frequently identified organisms were *Escherichia coli* (*E. coli*), *streptococci* and *Salmonella typhi*. The cumulative susceptibilities of these bacteria were compared using both TA and SA. A significant difference was found in the susceptibility rate of *E. coli* and *streptococci* species for fosfomycin, amikacin, nitrofurantoin, ampicillin and doxycycline between TA and SA. **Conclusion:** Our study clearly depicted the variations in isolated microorganism's susceptibility rate between a syndromic and traditional antibiogram. These differences may be significant, not only for selecting most effective empirical antimicrobial therapy for a patient but also helps in monitoring the resistance pattern of antibiotics to certain organisms within an institution.

Keywords: Antibiotics, Empiric therapy, Resistance, Syndromic Antibiogram, Traditional Antibiogram.

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INTRODUCTION

Antimicrobial Resistance (AMR) in bacterial pathogens poses a global challenge, contributing to elevated morbidity and mortality rates. The emergence of Multidrug-Resistant (MDR) patterns in both Gram-positive and negative bacteria has led to infections that are challenging to treat and, in some cases, they may even be untreatable with conventional antimicrobials. The alarming rise in emerging resistance, coupled with inadequate infection control practices, facilitates the spread of resistant bacteria among patients and the environment (Frieri *et al*., 2017). Hence, getting access to up-to-date epidemiological data on antimicrobial resistance in commonly encountered bacterial pathogen is valuable not only for determining treatment strategies but also for establishing effective AMSPs in hospitals (Akova, 2016).

The fundamental principle of AMSP involves establishing empiric antibiotic recommendations for commonly encountered infections, with antibiograms serving as a crucial tool for providing therapy guidance (Klinker *et al*., 2020). The hospital or traditional antibiogram is a periodic summary of the antimicrobial susceptibilities of local bacterial isolates submitted to the hospital's clinical microbiology laboratory. It is often used by clinicians to access local susceptibility rates as an aid in selecting empiric antibiotic therapy and in monitoring resistance trends over time within an institution (Truong *et al*., 2021). While most institutions rely on TA, recognizing the importance of integrating SA into clinical decisions enhances the effectiveness of empiric antibiotic therapy (Klinker *et al*., 2021).

Despite the TA reflecting local resistance patterns, there are several limitations, including (a) the absence of syndromic-specific recommendations; (b) typically lacking information on organism

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distribution for a specific infection; (c) limited utility for infections caused by two or more pathogens; and (d) being constructed using historical data that may not necessarily reflect current susceptibility data (Cook *et al.*, 2021). Appropriate empiric therapy is thought to be an important factor in improving clinical outcomes. To improve antibiotic treatment, prescribing must be based partly on infection epidemiology. The antibiogram has now evolved in complexity and utility from its traditional version into more modern forms, now capable of providing more accurate and useful information about antimicrobial susceptibility (Klinker *et al.*, 2022).

To guarantee patients receive the right empiric antibiotic treatment based on the suspected infection site, hospital location and patient characteristics, AMSPs need to extend their approach beyond TA. By collaborating with clinical microbiologists, AMSPs can effectively develop more advanced antibiograms to enhance the optimization of empiric antibiotic therapy (Klinker *et al.*, 2021). Hence, the present study aims to compare the susceptibility rate of traditional versus syndromic antibiogram to optimize empiric antibiotic therapy. The development of an infection-specific antibiogram increases the likelihood of appropriate antibiotic coverage before the organism is identified in culture. Additionally, it is useful for the surveillance of antibiotic resistance in hospital settings.

MATERIALS AND METHODS

Study design

This cross-sectional study was conducted over 6 months in a tertiary care hospital in Chennai. The study protocol was approved by the Institutional Human Ethics Committee (Ethical Clearance No.: IEC/2023/016) and the research was performed in conformance with the Helsinki Declaration.

Study population

This study included patients aged 18 and above with positive bacterial culture reports for Urinary Tract Infection (UTI), Respiratory Tract Infection (RTI) and Bloodstream Infection (BSI) associated with common pathogens such as *Escherichia coli* (*E. coli*), *streptococci* and *Salmonella typhi*. This study excluded patients with negative culture reports and positive culture reports of organisms other than the above-mentioned organisms. Based on the inclusion criteria, 400 samples were included in this study.

Data collection and study procedure

A data collection form was designed to record patient data like age, gender, IP no., OP no., patient location, diagnosis, sample collected, results of the culture report with antibiotic sensitivity and resistance pattern. To analyze the antibiotic susceptibility of the most common pathogens associated with UTI, RTI and BSI, SAs were developed and compared with TA. The TA included the three most common pathogens from all sources, while the SA considered the three most common pathogens from a specific source and patient location.

Antibiotic susceptibility testing

Clinical laboratory and Standard Institute guidelines, institutional protocols and hospital formulary were taken into consideration while choosing antibiotics. Antibiotics included in the analysis were chosen based on their availability and accessibility within the healthcare setting where the study was conducted.

Statistical Analysis

The collected data were analyzed using SPSS version 23 (SPSS Inc., Chicago, IL, USA). A chi-square test was used to compare the antibiotic susceptibility rate between TA and SA. A *p*-value

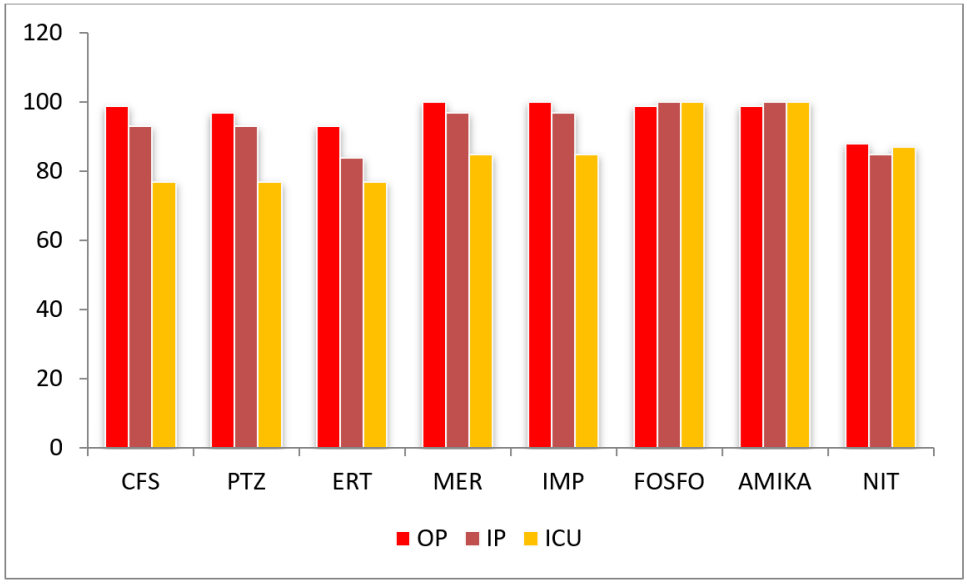

Figure 1: Antibiotic Susceptibility for *E. coli* based on Patient Location.

Table 1: Cumulative Susceptibility Rate for *E. coli*.

Antibiotics	TA (%)	SA (%)	*p* value
CFS	89	90	0.9999
PTZ	89	89	0.9999
ERT	84	85	0.9999
MER	90	94	0.4353
IMP	92	94	0.7828
FOSFO	89	100	0.0007*
AMIK	86	100	<0.0001*
NIT	75	87	0.0464*

(CFS-Cefoperazone sulbactam; PTZ-Piperacillin/tazobactam; ERT-Ertapenam; MER-Meropenam; IMP-Imipenam; FOSFO-Fosfomycin; AMIK-Amikacin; NIT-Nitrofurantoin).

Table 2: Cumulative Susceptibility Rate for *Streptococci* species.

Antibiotics	TA (%)	SA (%)	*p* value
PEN	92	94	0.9999
AMP	75	88	0.0279*
CLI	86	94	0.0970
DOX	60	82	0.0010*
VAN	82	85	0.7037
TEI	77	85	0.2067
LNZ	95	97	0.7209

(PEN-Penicillin; AMP-Ampicillin; CLI-Clindamycin; DOX-Doxycycline; VAN-Vancomycin; TEI-Teicoplanin; LNZ-Linezolid).

Table 3: Cumulative Susceptibility Rate for *Salmonella typhi*.

Antibiotics	TA (%)	SA (%)	*p* value
AMP	100	100	0.9999
CFM	95	96	0.9999
CTX	100	100	0.9999
CTR	100	100	0.9999
COT	100	100	0.9999
AZ	100	100	0.9999

(AMP-Ampicillin; CFM-Cefixime; CTX-Cefotaxime; CTR-Ceftriaxone; COT-Co-Trimaxazole; AZ-Azithromycin).

<0.05 was considered statistically significant at a 5% level of significance to the confidence interval of 95%.

RESULTS

A total of 400 bacterial isolates were examined, which consisted of 233 urinary isolates, 58 respiratory isolates and 59 blood isolates. The three most frequently identified organisms were *E. coli, Streptococci* and *Salmonella typhi*. We compared the cumulative susceptibilities of these bacteria using both TA and SA as shown in Tables 1-3 respectively. Antibiotic susceptibility for the above three bacteria based on patient location were represented in Figures 1-3.

Table 1 illustrates that a statistically significant difference was found in the susceptibility rate for FOSFO, AMIK and NIT between TA and SA.

Table 2 illustrates that a statistically significant difference was found in the susceptibility rate for AMP and DOX between TA and SA.

Table 3 illustrates that no statistically significant difference was found in the susceptibility rate between TA and SA.

DISCUSSION

Infectious diseases are controlled and cured with antimicrobial agents. Antibiotics pose different actions against microorganisms such as bacteriostatic and bactericidal mechanisms. The problem

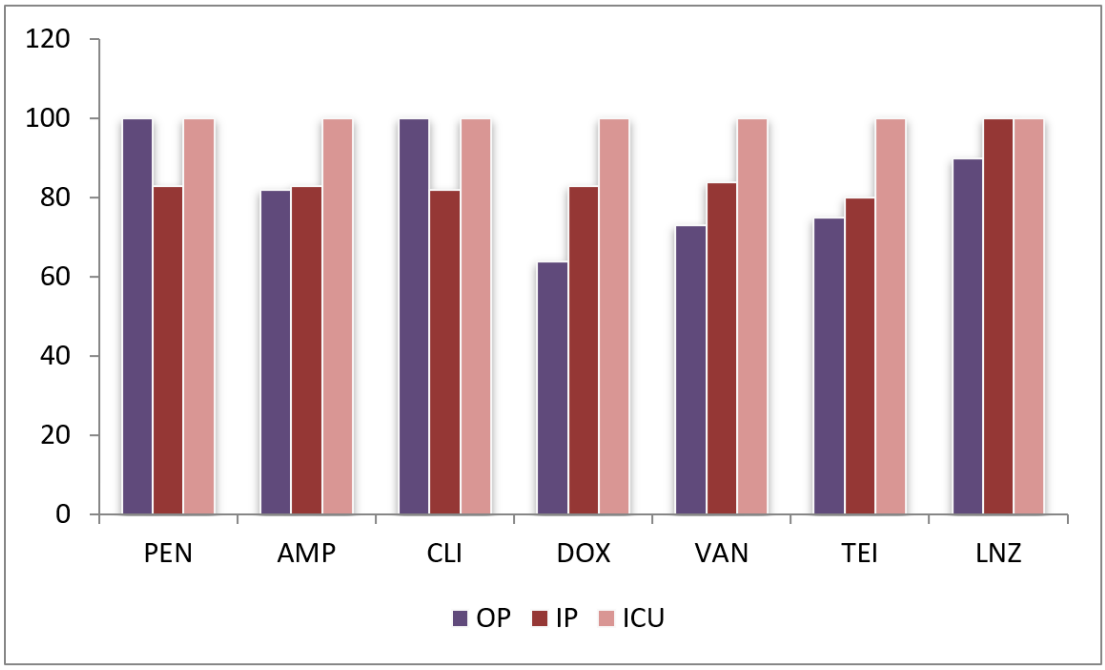

Figure 2: Antibiotics Susceptibility for *Streptococci* species based on Patient Location.

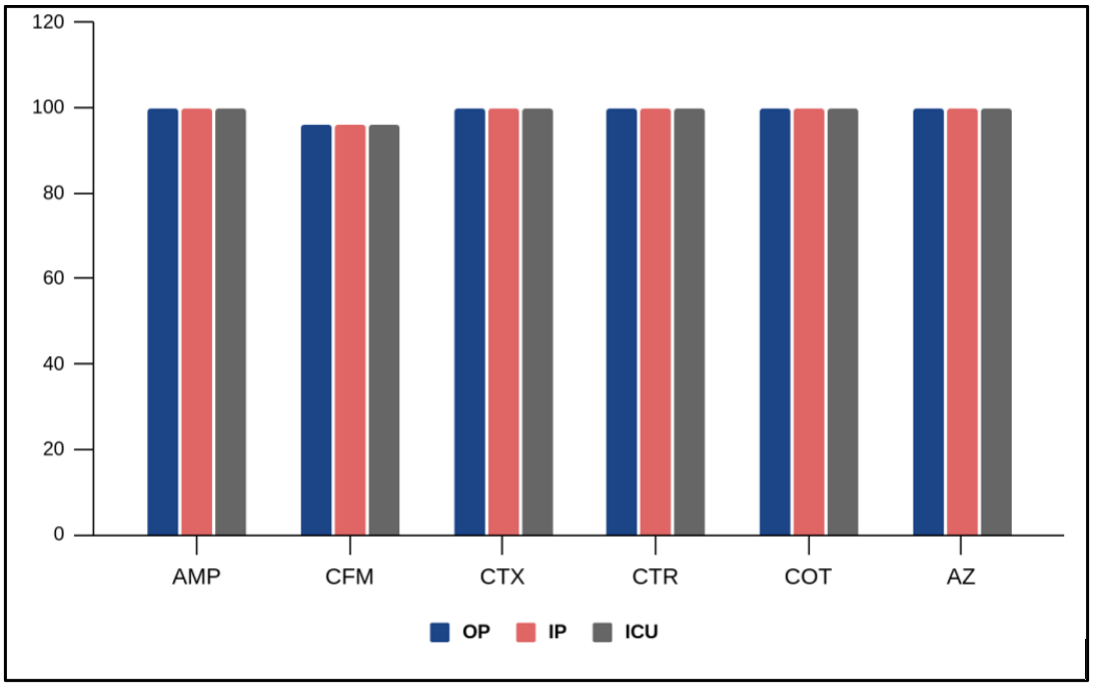

Figure 3: Antibiotics Susceptibility for *Salmonella typhi* based on Patient Location.

of antibiotic resistance emerged shortly after the discovery of antibiotics. Comprehending the pattern of resistance is important before continuing the use of current antibiotics (Abushaheen *et al.*, 2020). Though antibiotic resistance is a global health threat, India is one among other countries with high per-capita antibiotic consumption. Antimicrobial resistance claimed the lives of 1.27 million individuals across the globe in 2019. By 2050, it is predicted that Asia will experience 4.7 million deaths by antimicrobial resistance (Farooqui *et al.*, 2018).

Utilizing broad spectrum antibiotics as the first line of treatment is effective in targeting the common organisms believed to be responsible for the infection until the results of the culture test are available. Once the antibiotic susceptibility data are available and the etiologic pathogen has been identified, empiric therapy should be tailored to a definitive regimen (Altaf *et al.*, 2023). This may ultimately decrease the incidence of antibiotic resistance. Many bacterial infections persist, with UTI, RTI and BSI being frequently reported. UTIs are the predominant bacterial infection that is faced universally, regardless of age, gender, or location.

Furthermore, among certain groups such as pregnant women, UTIs enhance the risk of preterm delivery and miscarriage (Oli *et al.*, 2017). As a result, there is an increase in the frequency of prescribing intrapartum antibiotics prophylactically (Patangia *et al.*, 2022). Therefore, the careful selection of antibiotics improves the susceptibility rate.

Besides UTI, another significant factor contributing to the frequent use of antibiotics in adults is RTI (Huang *et al.*, 2022). The etiologic agent for RTI varies regionally, resulting in antibiotic susceptibility variation. This phenomenon results in increased consumption of over-the-counter antibiotics which directly paves the way for antibiotic resistance. BSIs impact about 30 million people, either through the invasion of bacteria into the blood or the spread of infection from other areas of the body. The advanced stage of BSI ends up with sepsis that requires proper medical attention and appropriate antibiotic therapy to lower mortality rate (Nestor *et al.*, 2021). Thus, monitoring the etiologic agent and their resistance pattern in BSI is very essential. Hence, the development of disease-specific antibiograms can be instrumental for hospitals seeking to develop antibiotic preservation programs like restricted antibiotic formularies (Al-Dahir *et al.*, 2015).

This study mainly focusing on effective strategies to develop SA for three common disease specific pathogens that have been compared with the susceptibility rate of TA. Cumulative susceptibilities for *E. coli, streptococci* and *salmonella* were compared between TA and SA. *E. coli* showed a significant difference in susceptibilities for fosfomycin, amikacin and nitrofurantoin (p=0.007, <0.001, 0.464). A Study conducted by (Gardiner *et al.*, 2019), shows that nitrofurantoin is effective in case of cystitis even during pregnancy (not beyond 38 weeks of gestation) also, many MDR organisms have high susceptibility towards nitrofurantoin and development of resistance is very rare. They also say that, uniqueness in the structure of fosfomycin aids in minimizing the cross-resistance with other antibiotics. Hence, many MDR isolates retain their susceptibilities to fosfomycin (Gardiner *et al.*, 2019). Nowadays cases of UTI caused by ESBL-EC are increasing and studies show that amikacin is effective in treating it (Cho *et al.*, 2015). There is a constant change in UTI antibiogram due to empiric antibiotic overuse (Oli *et al.*, 2017).

Streptococci showed a significant difference in susceptibilities for ampicillin and doxycycline (p=0.0279 and 0.0010). Studies reveal that ampicillin provides effective treatment for RTI when the etiological agent is *S. pneumoniae* (Cilloniz *et al.*, 2018). The main aim of developing ampicillin was to prevail over certain drawbacks of penicillins such as broad-spectrum coverage and development of resistance (Majhi *et al.*, 2014). The Infectious Diseases Society of America suggests doxycycline as an alternative drug for penicillin allergic patients. (Dallas *et al.*, 2013), compared tetracycline with doxycycline and reported that, while considering MIC values doxycycline is more effective than tetracycline.

Overall, our study revealed that TA showed lower susceptibilities for *E. coli* and *Streptococci* when compared to SA. The variability in susceptibility rate may be due to the inclusion of isolates from all the samples in TA (Klinker *et al.*, 2020) in contrast to SA which included samples only from urine and respiratory samples.

But in case of salmonella, no significant difference was seen between TA and SA, as in our study salmonella was present only in blood samples. Thus, TA may misguide the clinician, as it does not accurately reflect the susceptibility rate of antibiotics. Hence, there is a need for developing infection specific antibiograms to ensure that the patient receives appropriate empiric antibiotic therapy based on the suspected site of infection and the etiologic agent (Klinker *et al.*, 2021).

CONCLUSION

According to our research findings, it is evident that TA does not accurately reflect the susceptibility rate of antibiotics when compared to SA. The research clearly demonstrates the disparities in susceptibility rates of isolated microorganisms between a syndromic and traditional antibiogram. These differences are crucial, not only for selecting most effective empirical antimicrobial therapy for a patient but also helps in monitoring the resistance pattern of antibiotics to certain organisms within a healthcare setting. Therefore, we suggest integrating syndrome-specific susceptibility data in an institution's antibiogram to enhance guidance for clinicians in choosing appropriate empiric therapy for individual patients.

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CONFLICT OF INTEREST

The authors have no relevant financial or non-financial interests to disclose.

CONSENT TO PARTICIPATE

Informed consent was obtained from all individual participants included in the study.

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