A NOMOGRAM-BASED PREDICTIVE TOOL FOR DETECTING ESBL-PRODUCING ENTEROBACTERIACEAE IN UTI' S

Nawaz Sadiqu Cp, Rida Abdul Rasheed, Shizin Ahammed, Sinan Firoz, Saleem Malik, and Saleem Malik

Department of Computer Science and Engineering, P. A. College of Engineering, Karnataka, Mangaluru, India

E-mail:

Abstract

Urinary tract infections or shortly known as UTI's are widespread and increasingly complicated by drug-resistant pathogens. This project presents a data-informed clinical model, PURSUIT, aimed at predicting resistance and aiding treatment decisions. This study introduces the clinically-driven PURSUIT model to predict antibiotic resistance and ESBL-producing microbes in UTI patients. Demographics, clinical history, comorbidities, and antibiotic exposure were examined in over 6,000 patient records. To help doctors choose empirical treatments, multivariate logistic regression identified resistance risk factors and generated a nomogram. The method's diagnostic accuracy and reliability could prevent antibiotic usage and enhance patient outcomes. Primary care and hospitals use PURSUIT to alter antibiotic medication and prevent uropathogen resistance. Clinical use could increase antibiotic stewardship and personalize UTI care.

ISBN:97881-19905-39-3

1 Introduction

The rising threat of antibiotic resistance is closely linked to the widespread and often unregulated use of antimicrobial drugs. In countries like India, where infectious diseases are highly prevalent, the demand for antibiotics has surged, making it one of the top consumers globally. This increasing consumption, while necessary in many cases, contributes significantly to the development of drug-resistant bacterial strains. In response, international health organizations have stressed the importance of using antibiotic resistance data to inform treatment strategies and minimize unnecessary drug exposure. Initiatives like the WHO's global action plan advocate for evidence-based practices, enhanced surveillance, and improved antibiotic stewardship across healthcare systems.

UTI's commonly caused due to bacteria such as Escherichia coli and Klebsiella pneumoniae, are among the most frequent bacterial infections treated in both hospitals and communities. A growing concern is the emergence of strains that produce Extended-Spectrum Beta-Lactamases (ESBLs), which render standard antibiotics ineffective. Such resistant strains are becoming increasingly common, particularly in regions of Asia, leading to delays in treatment and higher risks of complications. In India, the frequency of ESBL-producing pathogens underscores the urgency for better diagnostic and predictive tools.

Treating UTIs empirically—before lab results are available—often leads to incorrect antibiotic choices when local resistance patterns are not considered. This study presents a novel predictive model designed to estimate the risk of ESBL-producing infections using only basic clinical history and patient information. By avoiding the need for additional tests, this model aims to support immediate and informed decisions, helping clinicians choose more appropriate initial therapies and reduce the misuse of broad-spectrum antibiotics.

ISBN:97881-19905-39-3

2 Literature Survey

The WHO and other international health authorities warn that antimicrobial resistance (AMR) is a worldwide health hazard. Due to their developing antibiotic resistance, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacteriaceae were named the top priority drug-resistant organisms by the WHO in 2017. In India, the situation is worrisome. India is called the "antibiotic capital of the world" due to its high antibiotic use and AMR rate. Recently, important uropathogens such E-coli and Klebsiella pneumoniae have developed fluoroquinolone, cephalosporin, and carbapenem resistance.[1] ESBL strains are currently prevalent in hospitals and communities, with 94.1% positive in some places.[2]

E-coli and K-pneumoniae, are found to be resistant to antibiotics like nitrofurantoin and cephalosporins, causing most community- and hospital-acquired UTIs. Few effective treatments,like carbapenems, are being done although resistance is rising. Resistance in E-coli isolates in India is linked to certain β-lactamase genes such blaCTX-M and blaTEM, with CTXM-15 being the most prevalent. The extensive dissemination and great resistance of sequence type ST131 clones[4]. Given these obstacles, predictive methods and models that can identify antibiotic-resistant infections early are needed to help doctors choose suitable therapeutic regimens and improve patient outcomes.[3]

3 Methodology

The PURSUIT model predicts resistance patterns, particularly to ciprofloxacin, ceftriaxone, and cotrimoxazole which are some commonly prescribed antibiotics. The study used a retrospective cohort analysis of nearly 6,000 UTI-symptomatic SSSIHMS-PG Urology Department patients. Prospectively gathered data on culture-positive UTI cases, focusing on E. coli and Klebsiella pneumoniae isolates (85%). The study included age, gender, recent catheterization, history of urinary tract interventions, anomalies, hospitalization, antibiotic use, and comorbidities like diabetes or immunosuppression. Those that were accessible

ISBN:97881-19905-39-3

during patient engagement without invasive testing were chosen.

Standard clinical methods were used to culture urine samples for microbiological validation. The isolates were tested for antibiotic susceptibility using Kirby-Bauer disk diffusion. Phenotypic assays with cefotaxime and ceftazidime with or without clavulanic acid were used to detect ESBL (Extended Spectrum β-Lactamase). Logistic regression was used to find independent resistance factors. The significant variables were included in a nomogram, a

graphical prediction tool that helps clinicians assess patient resistance. The PURSUIT model revolves around this nomogram. The study could also use Decision Trees, Random Forests, or SVM to improve predictive accuracy, especially in clinical decision support systems. These algorithms, trained on the labeled dataset, may categorize fresh patient data as antibiotic-resistant or sensitive. Specificity, accuracy, sensitivity, and ROC curve area are the metrics used to evaluate model performance.

This integrated approach of statistical modeling and clinical microbiology makes the PURSUIT model data-driven and clinically applicable. The approach helps clinicians choose empirical medicines to reduce treatment failure, antibiotic abuse, and healthcare antibiotic stewardship.

4 Result

The PURSUIT study provides a detailed assessment of UTI patients' microbiological and demographic patterns. 1,397 (23%) of 6,038 urine samples collected between January 2019 and August 2022 were culture-positive.[4] The most common culprits were Escherichia coli (52%) and Klebsiella pneumoniae (32%). A high rate of resistance to routinely administered antibiotics like ciprofloxacin, ceftriaxone, and cotrimoxazole highlights the need for an effective prediction model like PURSUIT to improve empirical treatment.

The demographic research found that the age of most patients were over 60, with a

ISBN:97881-19905-39-3

balanced gender split. Recently hospitalized, catheterized, or antibiotic-treated patients had more MDR infections. This permits adding these parameters to the predictive nomogram. Patients with diabetes and frequent urinary operations had higher resistance rates.

Resistance factors against antibiotics were found using multivariable logistic regression. Hospitalization, antibiotic use, catheterization, male gender, and older age were factors. The nomogram from these predictors predicted resistance to all three drugs with an AUC over 0.75 in figures 2 and 3. Thus suggesting that the model could influence empirical therapeutic decisions in clinical situations.

It also showed that many E-coli and Klebsiella isolates produced ESBL. Hospitalized patients and those with a number of risk factors had more ESBL-producing strains. These findings emphasize the necessity to forecast ESBL-producing organisms to prevent providing ineffective antibiotics, especially third-generation cephalosporins.

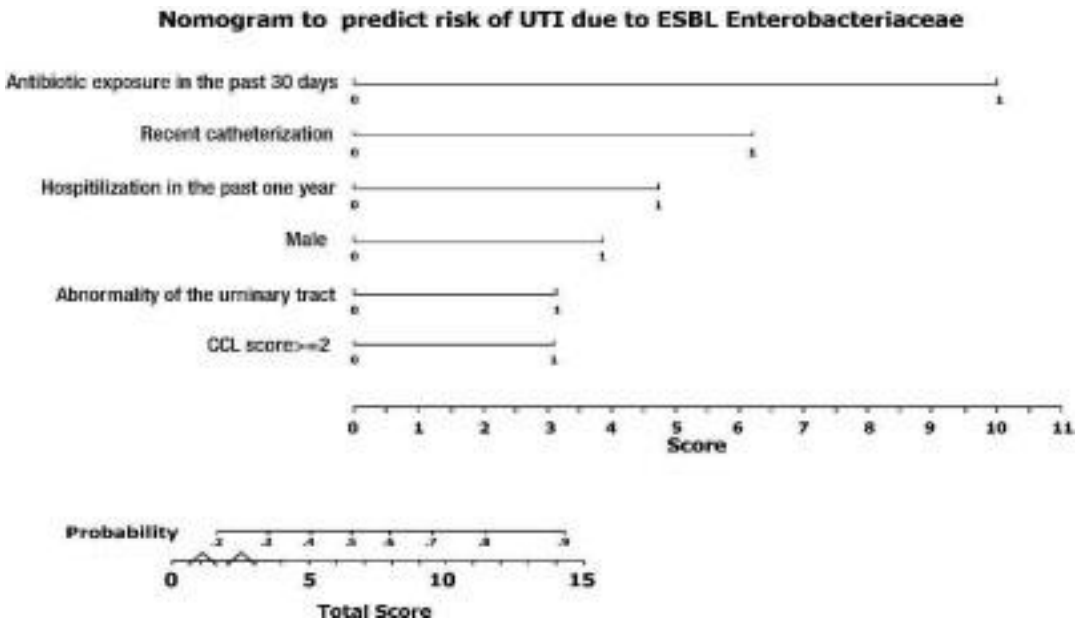

Figure 1:

ISBN:97881-19905-39-3

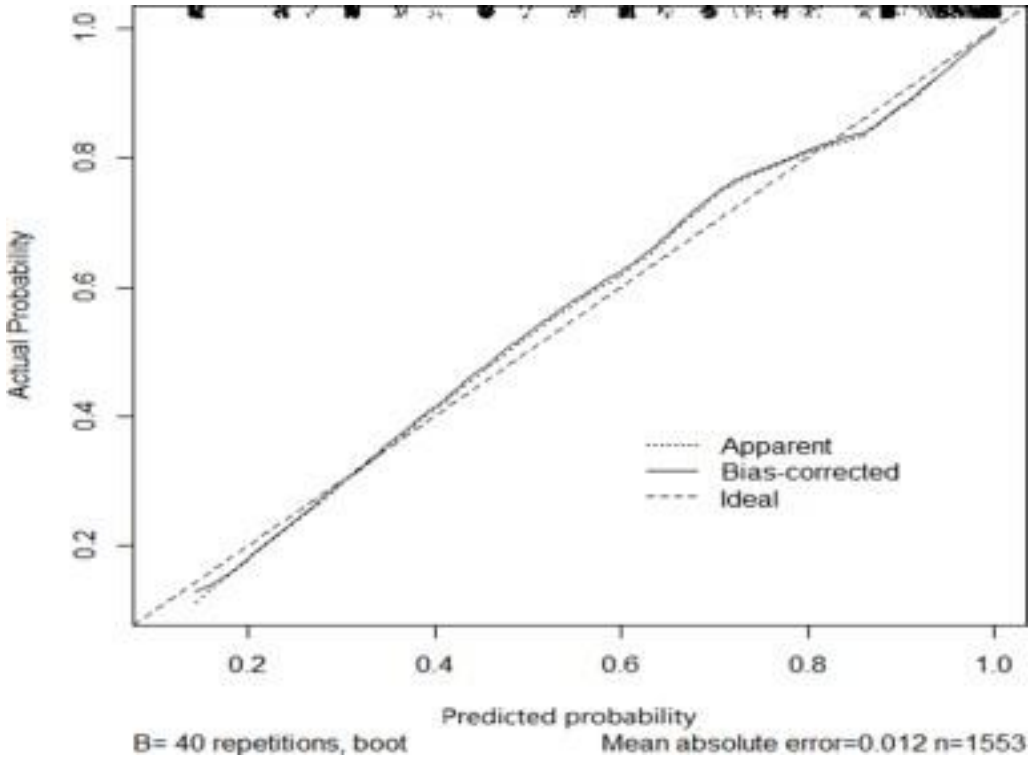

Figure 2:

5 Conclusion

Because of the predominance of resistant organisms like E-coli and Klebsiella pneumoniae, the PURSUIT model can help combat antibiotic resistance in urinary tract infections (UTIs). The study found significant risk variables such prior antibiotic usage, recent hospitalization, catheterization, and concomitant diseases by analyzing clinical, demographic, and microbiological data from nearly 6,000 individuals. A predictive nomogram with high diagnostic accuracy and reliability used these.

The PURSUIT model helps clinicians choose antibiotics by estimating resistance to common antibiotics and ESBL-producing microbes. This can reduce treatment failures, minimize broad-spectrum antibiotic use, and improve antibiotic stewardship.

The model could be improved with real-time data from different centers and machine learning-based classifiers to improve forecast precision. Electronic health records may also enable wider clinical use. The PURSUIT framework is a strong, evidence-based strategy to

ISBN:97881-19905-39-3

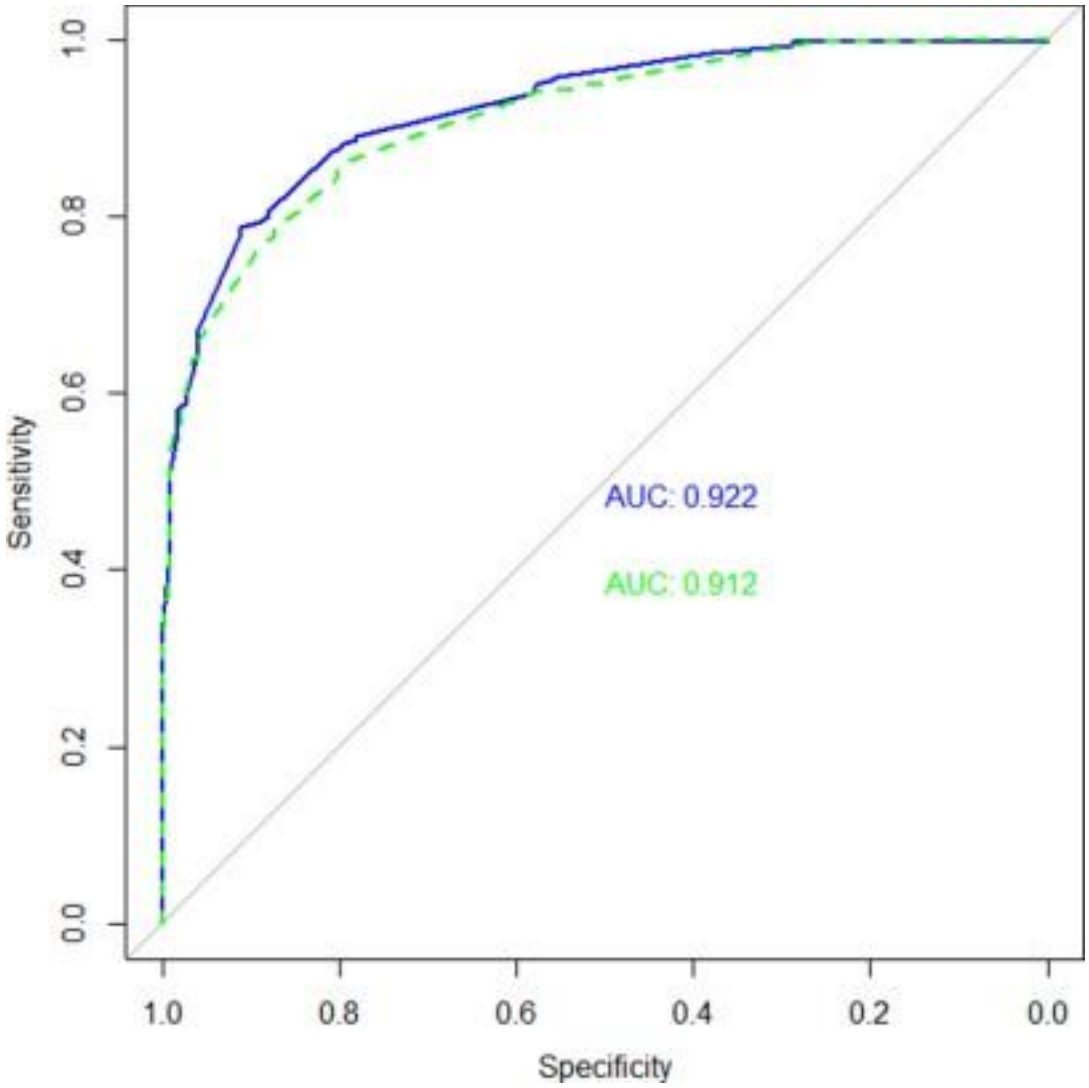

Figure 3:

prevent UTI antibiotic resistance with high scalability and clinical impact.

References

(1) Hasandka, A.; Singh, A. R.; Prabhu, A. Paper and thread as media for the frugal detection of urinary tract infections (UTIs). *Anal Bioanal Chem* **2022**, *414*, 847–865.

(2) Chandra, S. Extended-Spectrum Beta-Lactamase Infections. *Curr Emerg Hosp Med Rep* **2013**, *1*, 145–148.

ISBN:97881-19905-39-3

(3) Gomila, A.; Shaw, E.; Carratalà, J. Predictive factors for multidrug-resistant gram-negative bacteria among hospitalised patients with complicated urinary tract infections. *Antimicrob Resist Infect Control* **2018**, *7*, 325–332.

(4) Yoon, S.; Kim, H.; Kim, S. W. Fever lasting 48 hours as a predictive factor of ESBL-producing bacteria in non-critically ill patients with urinary tract infection. *Sci Rep* **2024**, *14*, 10897–10897.

ISBN:97881-19905-39-3