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Prevalence and Antibiotic Susceptibility Patterns of *Streptococcus pneumoniae* isolated from hospitalized pneumonia patients in Beed, Maharashtra, India

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A B S T R A C T

Streptococcus pneumoniae is the most common cause of community-acquired and hospital-acquired pneumonia globally with little data on surveillance in semi-urban India. The ensuing spread of antimicrobial resistance has added to the complexity of the treatment outcomes especially in the under-resource districts like Beed, Maharashtra. In all, 150 throat swab specimens of clinically suspected pneumonia patients were obtained in four wards lasting 12-months between January 2022 and December 2022. *S. pneumoniae* was isolated and identified by classical phenotypic and biochemical testing including Gram staining, haemolysis, optochin susceptibility, bile dissolution and sugar fermentation patterns. Confirmed isolates were tested for antibiotic susceptibility with a broad spectrum of 0-lactams, macrolides, fluoroquinolones, tetracyclines, glycopeptides, carbapenems, and other agents which were interpreted according to CLSI guidelines. Out of 150 samples, 109 (72.6%) were confirmed as *S. pneumoniae*, with the highest distribution in ICU patients (28.4%). Males accounted for 56% of isolates. Antimicrobial susceptibility testing revealed high resistance to penicillin (47.7%), ampicillin (47.7%), azithromycin (70.6%), clindamycin (45%), tetracycline (42.2%), and trimethoprim–sulfamethoxazole (56.9%). In contrast, newer cephalosporins such as ceftaroline (81.6%) and cefepime (78.0%), along with carbapenems (78–81%), vancomycin (100%), linezolid (98.2%), and tigecycline (100%), demonstrated strong efficacy. Fluoroquinolones exhibited moderate susceptibility, with levofloxacin being the most effective (71.6%). The prevalence of S. pneumoniae multidrug-resistant strains is a concern in Beed; this incredibly represents both deficiencies in diagnosis and stewardship. The use of last-line antibiotics highlights the need to adopt rational prescribing, improve on vaccination coverage, and increase local resistance surveillance in order to minimize morbidity, mortality, and economic cost.

Introduction

Pneumonia is one of the leading infectious causes of morbidity and mortality globally, affecting especially children, the elderly, and immunocompromised individuals (Aleem *et al.,* 2020; Lim, 2021). The most common bacterial pathogen that causes community-acquired pneumonia and invasive pneumococcal diseases namely, meningitis and septicaemia is *Streptococcus pneumoniae (S. pneumoniae)* (File, 2004; Dhawale *et al.,* 2025). The World Health Organization estimates that pneumococcal disease leads to the death of over 300,000 children per year mostly in a low- and middle-income country where vaccination and diagnosis are inaccessible (WHO, 2023). It was reported in the Global Burden of Disease study that in 2019 lower respiratory tract infections, and, specifically, pneumococcal pneumonia was the leading cause of infectious death in all age groups, with 2.49 million dying worldwide (Troeger *et al.,* 2018).

Pneumonia is also a significant health issue in India making up approximately 15% of deaths caused by preventive diseases of under-five children according to the ICMR in 2020, with 30-40% of the severe cases hospitalized due to *S. pneumoniae* (ICMR, 2020). The precise establishment (all over the country types of surveillance studies) have shown the amount of isolation of pneumococcal between 20 and 43% in youngsters with pneumonia, thus supporting its standing as a gamechanger pathogen (Rodgers & Klugman, 2015). The actual burden may be underestimated, though, in rural or semi-urban areas (e.g. Maharashtra), where little surveillance exists and access to microbiological diagnostics is poor.

The challenge of antimicrobial resistance that is on the increase also adds complexity to control of pneumococcal infection. *S. pneumoniae* has been becoming resistant to a range of antibiotics such as macrolides, sulphonamides, and fluoroquinolones since the initials resistance to penicillin was reported in 1960s (Kim *et al.,* 2016). It has been prioritized as a pathogen of resistance interest by the world health organization (WHO, 2017). The proportion of isolates that are resistant to at least one of the most frequently used antibiotics ranges between 30 and 50 % globally, and multidrug resistance is growing (Cillóniz *et al.,* 2018). The rates of resistance are of an even greater concern in India. According to a report given by Veeraraghavan and Kurien (2011), resistance to penicillin has been as high as 30% among isolates and over 40 percent in some centers against erythromycin. Beta-lactam, macrolide, and cotrimoxazole classes that remain common empirical treatments were verified to be resistant on a large scale by Chawla *et al.* (2010). These tendencies can be conditioned by non-rational prescriptions, available sales of antibiotics without a prescription and lack of effective antimicrobial stewardship programs. The problem is especially severe in the semi-urban regions of the country such as Beed, Maharashtra, which has a problem with reminder limitations, empirical treatment without culture, and insufficient awareness (Feldman & Anderson, 2014).

The drug resistance of *S. pneumoniae* leads to serious outcomes. Increased resistance has been associated with treatment failures, extended stays as well as time in a hospital, elevated ICU admissions as well as mortality (File, 2006). The approximate annual amount of resistant pneumococcal infections as well as the consequence of the costs to the healthcare of the United States comes to an estimation of USD 1.5 billion (Chen *et al.,* 2019). The antimicrobial resistance is estimated to cost the world up to USD 100 trillion by 2050 in the case of unbridled mass consumerism in 2020 (O Neill, 2016). These statistics are the reminder of the need to reinforce localized surveillance to inform rational use of antibiotics and empirical treatment. The introduction of pneumococcal conjugate vaccines has been an important milestone toward lessening the burden of disease. In 2017, India has included the 13-valent pneumococcal conjugate vaccine (PCV13) in its Universal Immunization Programme and early data indicate that this introduction to the schedule has resulted in strong drops in invasive disease and childhood mortality (Kumar *et al.,* 2025). But it is being covered unevenly, particularly in areas such as Beed (rurally located) where there is a dearth of awareness and access to the same. Additionally, PCV13 does not cover all the resistant serotypes, and this is why there must be a constant tracking of circulating types of strains and their resistance rates.

Although a lot of research has been carried out by large centres in India, there is a paucity of data at the district level. The local and national variations may be seen in resistance patterns such as in the places where different antibiotics, vaccine rates and prescribing habits vary. Besides, there is little literature concerning drugs like cephalosporins and fluoroquinolones, which are more current compared to penicillin, erythromycin, and cotrimoxazole in semi urban settings. Such absence of regional evidence makes it difficult to prescribe effective

therapies by clinicians and is a factor that leads to poor outcomes. The given study therefore contextualizes a significant knowledge gap by recording the incidence and appositeness of *S. pneumoniae* on patients hospitalized due to pneumonia in Beed district. Scientifically, it will give fundamental baseline information on local epidemiology of pneumococcal resistance, which can be utilized in formulation of empirical treatment guidelines and stewardship policies. On a social end, it puts a strong emphasis on the necessity of rational antibiotics usage, microbiological testing of patients before treatment, and the increase of vaccination in under-serviced districts. The results will be used to inform clinicians on the proper therapeutic modes to choose, minimize cases of treatment failure, and diminish morbidity and mortality within the area.

The study provides experimental evidence to reinforce clinical decision and policy in India, as the local data on pneumococcal disease and resistance can be put in the context of the disease and resistance at the global and Indian high. The expectations of these findings are that apart from helping in the better management of patients in Beed, the process will also be replicated by other semi-urban and rural areas that are facing the twin menace of pneumococcal disease and antimicrobial resistance.

Materials and Methods

Specimen Collection and Transportation

On basis of one patient's one sample strategy. A total of 175 throat swab specimens were collected during January to December 2022 from patients who were clinically suspected of pneumococcal infection in General Medicine, Pediatric, ICU as well as Respiratory Medicine wards of XXXX The Culture Transport Swabs with Amies medium and charcoal (HiMedia, India) were used to collect samples in order to maintain the viability of bacterial cells. All collected Specimens were transported to the microbiology laboratory aseptically on the cold chain under appropriate conditions. All specimens were processes to consider the bacterial growth with respect to isolation and identification of *S. pneumoniae*.

Isolation, identification and characterization of *S. pneumoniae*

The throat swabs were inoculated in the 5% sheep blood agar (SBA, Hi-Media, India) and incubated under the aerobic environment at 37^0C in the carbon dioxide (CO_2) incubator overnight. The morphology of the colony was examined next day. Gram stain was used to stain the bacteria that form small, circular and semi-transparent colonies with a beta-haemolytic halo (zone) around them. Suspected pure Streptococcal colonies from a fresh culture grown on 5% SBA were further processed for confirmation through Gram staining and biochemical tests i.e. catalase, oxidase, optochin disc test, bacitracin disc, different sugars fermentation profiling as per previously published protocols.

Table.1 Distribution of 150 throat swab specimens according to hospital ward and gender

Ward	Male	Female	Total
General Medicine	21	17	38
Pediatrics	19	15	34
ICU	24	19	43
Respiratory Medicine	20	15	35
Total	**84**	**66**	**150**

Assessment of Antimicrobial Susceptibility Patterns of *S. pneumoniae* Isolates

A pure colony of confirmed *S. pneumoniae* was emulsified in sterile 0.85% saline to achieve turbidity equivalent to a 0.5 McFarland standard (~1.5 × 10^8 CFU/mL), and the suspension was used immediately for inoculation. Standardized inoculum was evenly swabbed in three directions onto Mueller–Hinton agar (HiMedia, India) supplemented with 5% defibrinated sheep blood to ensure a uniform bacterial lawn. Antibiotic susceptibility testing was performed using discs of clinically relevant agents, including β-lactams (ampicillin 10 µg, amoxicillin–clavulanate 20/10 µg, cefepime 30 µg, cefotaxime 30 µg, cefpodoxime 10 µg, ceftaroline 5 µg, ceftazidime 30 µg, ceftriaxone 30 µg, cefuroxime sodium 30 µg, cefuroxime axetil 30 µg, oxacillin 1 µg, penicillin G 10 units), macrolides (azithromycin 15 µg, erythromycin 15 µg), fluoroquinolones (ciprofloxacin 5 µg, gatifloxacin 5 µg, gemifloxacin 5 µg, levofloxacin 5 µg, moxifloxacin 5 µg), tetracyclines (doxycycline 30 µg, minocycline 30 µg, tetracycline 30 µg, tigecycline 15 µg), and other key agents such as chloramphenicol 30 µg, clindamycin 2 µg, daptomycin 30 µg, linezolid 30 µg, rifampin 5 µg, streptomycin 300 µg, trimethoprim–sulfamethoxazole 1.25/23.75 µg, meropenem 10 µg, and vancomycin 30 µg. Discs were applied aseptically and plates incubated at 35–37°C in 5% CO_2 for 20–24 hours.

Following incubation, inhibition zone diameters were measured with a digital calliper and interpreted according to the latest CLSI guidelines, classifying isolates as susceptible, intermediate, or resistant.

Results and Discussion

Among the 150 throat swab clinical specimens retrieved from patients who were clinically suspected of having pneumonia infection due to *S. pneumoniae* across four hospital wards, overall, 109 (72.7%) specimens yielded *S. pneumoniae* isolates. The isolates were distributed differently by ward and gender Figure 1. The grater number of positive isolates was observed in the ICU (n = 31; 28.4%). subsequently General Medicine ward (n = 27; 24.8%), the Respiratory Medicine ward (n = 26; 23.9%), and the Pediatrics ward (n = 25; 22.9%).

Differences were also observed on basis of gender. Among the 109 isolates, 61 (56%) were obtained from male patients and 48 (44%) from female patients. The highest male-to-female disparity was seen in the Respiratory Medicine ward, where 57.7% (15/26) isolates were from males compared to 42.3% (11/26) from females. Likewise, in the ICU, 54.8% (17/31) isolates were from males and 45.2% (14/31) from females, while in the General Medicine ward, 55.6% (15/27) isolates were from males and 44.4% (12/27) from females. The Pediatrics ward also represented this gender imbalance, with 56% (14/25) isolates in males versus 44% (11/25) in females.

Biochemical Identification of *S. pneumoniae* Isolates

Among all the 150 suspected streptococcal isolates tested, 109 (72.6%) were confirmed as *Streptococcus pneumoniae*, showing Gram-positive lancet-shaped diplococci with alpha-hemolysis, negative catalase and oxidase reactions, clear optochin sensitivity (≥14 mm), bile solubility, and consistent fermentation of inulin, glucose, and sucrose (Table-2). The remaining 41 isolates (27.3%) were identified as non-pneumococcal Streptococci strains due to optochin resistance, bile insolubility, and variable sugar fermentation profiles.

Antimicrobial Susceptibility Patterns of *S. pneumoniae* Isolates

Phenotypic antibiogram profiling of *S. pneumoniae* isolates (n = 109) represented variable susceptibility across different antibiotic classes (Figure 2).

Penicillin (52.3%) and ampicillin (52.3%) showed minimize activity, while amoxicillin–clavulanate showed 58.7% susceptibility with resistance in 22.0% of isolates. Third-generation cephalosporins were more effective, with ceftriaxone (79.8%) and ceftazidime (76.1%) showing higher activity, whereas cefotaxime achieved only 61.5%. Cefepime (78.0%) and ceftaroline (81.6%) were among the most effective β-lactams, while cefuroxime axetil (51.4%) and cefuroxime sodium (48.6%) were less effective. Macrolides demonstrated higher resistance, with azithromycin susceptibility at 29.4% and clindamycin resistance in 45.0%. Fluoroquinolones demonstrated moderate activity, with ciprofloxacin (63.3%), levofloxacin (71.6%), and moxifloxacin (67.9%), though resistance remained between 13–22%. Tetracyclines produced unpredictable results, tetracycline (57.8%) and minocycline (64.2%), but tigecycline represented complete susceptibility (100%). Glycopeptides were highly active, shiwing, vancomycin (100%) and linezolid (98.2%) showing excellent activity, and daptomycin (92.7%) also highly effective. Rifampin (81.6%) and carbapenems, including imipenem (78.9%) and meropenem (80.7%), showed strong performance. By contrast, trimethoprim–sulfamethoxazole was was not as effective, with susceptibility of only 43.1% and resistance in 32.1% of tested isolates (Figure 3).

Quantitative analysis with heatmap projections of *S. pneumoniae* susceptibility pattern (n=109) show considerable heterogeneity among the different tested antibiotic classes, with β-lactams having limited overall activity (52.3% susceptible, 33.9% resistant), cephalosporins presented high efficacy (68.1% susceptible) and carbapenems remaining highly active. Earlier derivatives like penicillin or ampicillin were considerably less resistant whilst more novel 7-lactams such as cefepime (78.0%) and ceftaroline (81.6%) were highly active. The least effective class was macrolides with resistance to azithromycin of less than one-third (29.4%) and resistance to clindamycin of 45.0%, as is evident of pervasive macrolide resistance. The fluoroquinolones were more active (6072 per cent susceptible) though clinically meaningful resistant remained. The results with tetracyclines were variable and minocycline compared to tetracycline was more effective (64.2% versus 57.8%), whereas tigecycline showed full activity (100%). In comparisons with this,

activity levels of last-line and advanced agents were promising: vancomycin (100%), linezolid (98.2%), and daptomycin (92.7%) proved to be highly active. Good activity was also shown by rifampin (81. 6%) and carbapenems (78-81%), the use of trimethoprim-sulfamethoxazole was inconsistent and had weak susceptibility of 43.1% only. In combination, these data highlight the continuing widespread resistance to the traditional first-line antimicrobials, such as penicillin, ampicillin, macrolides, clindamycin, tetracycline, and cotrimoxazole, whereby activity of newer β-lactams, tigecycline, daptomycin, linezolid, and vancomycin has remained intact hence leading to greater clinical dependence on newer antibiotics in treating pneumococcal infections.

Figure.1 Distribution of *S. pneumoniae* isolates

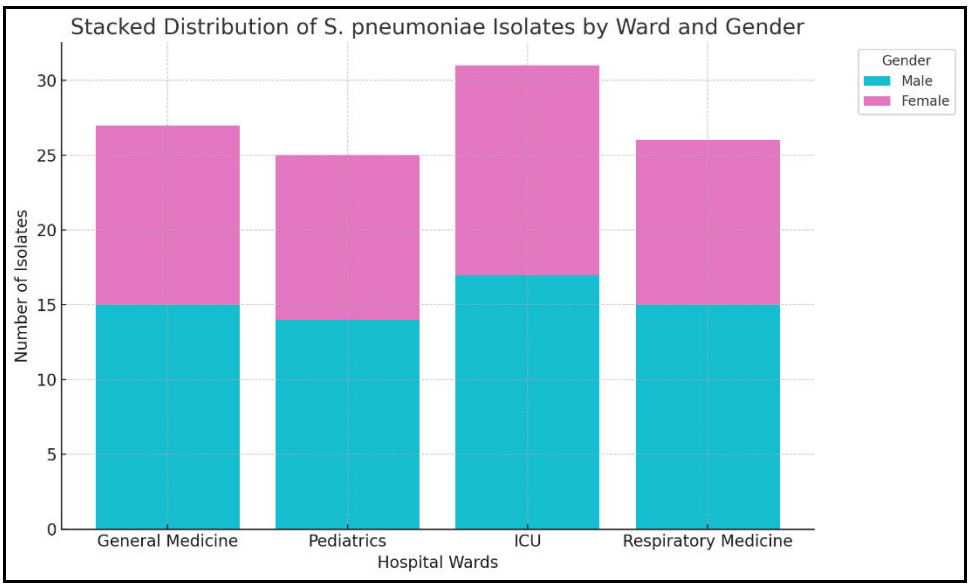

Figure.2 Antibiogram Pattern Designed on basis of Antibiotic Classes

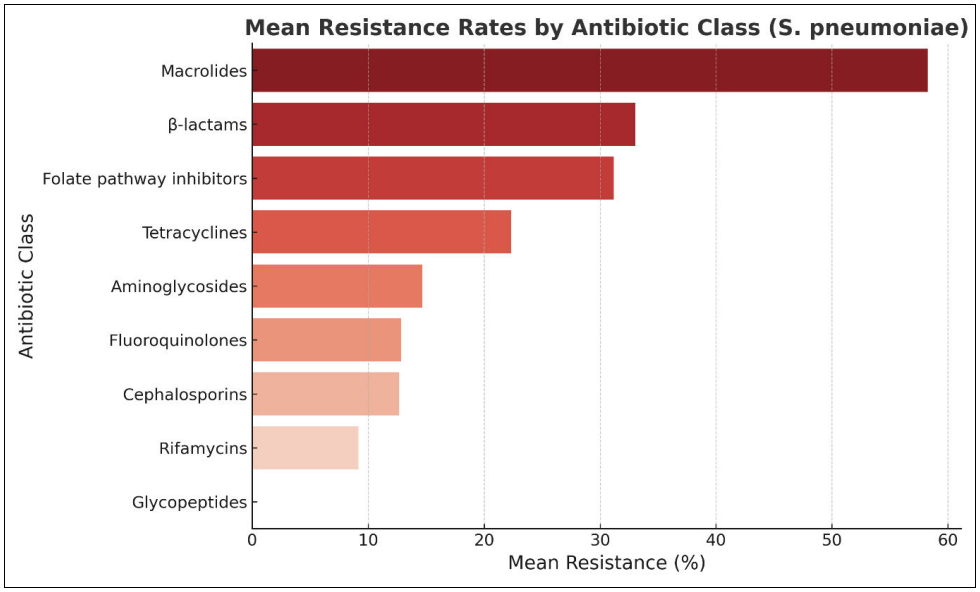

Figure.3 Antibiogram Pattern Observed in Preseant Investigation

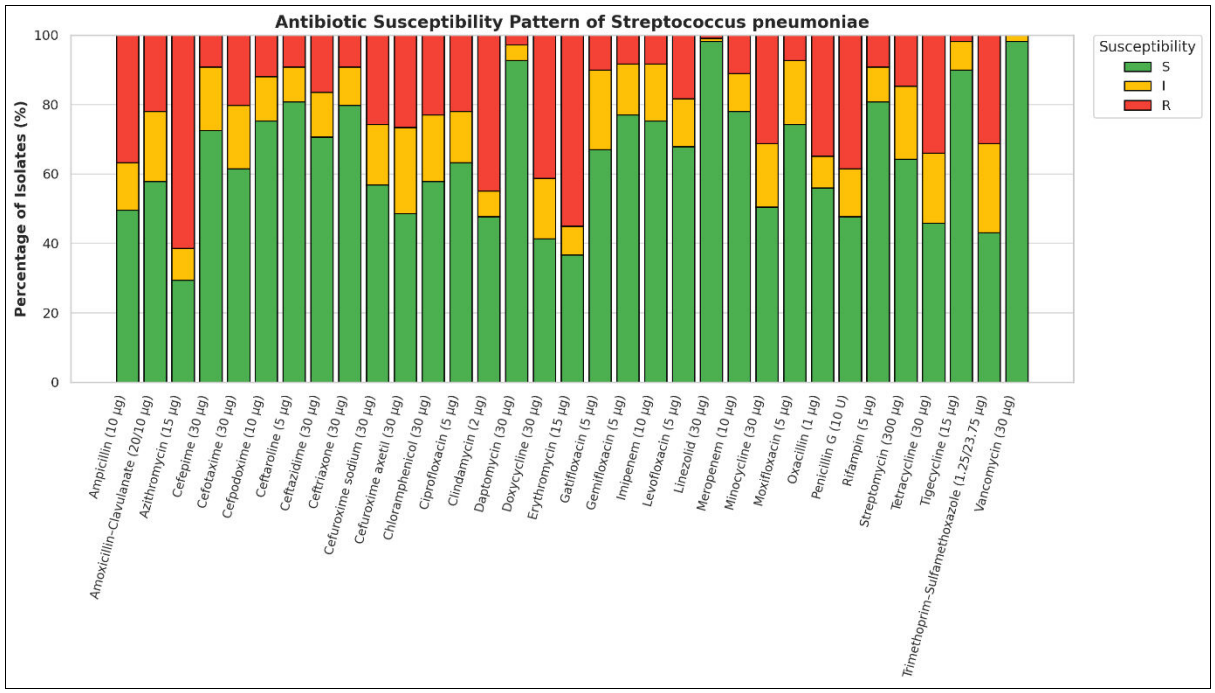

Figure.4 Heatmap Visualization of Antibiogram Pattern of *S. pneumoniae* isolates

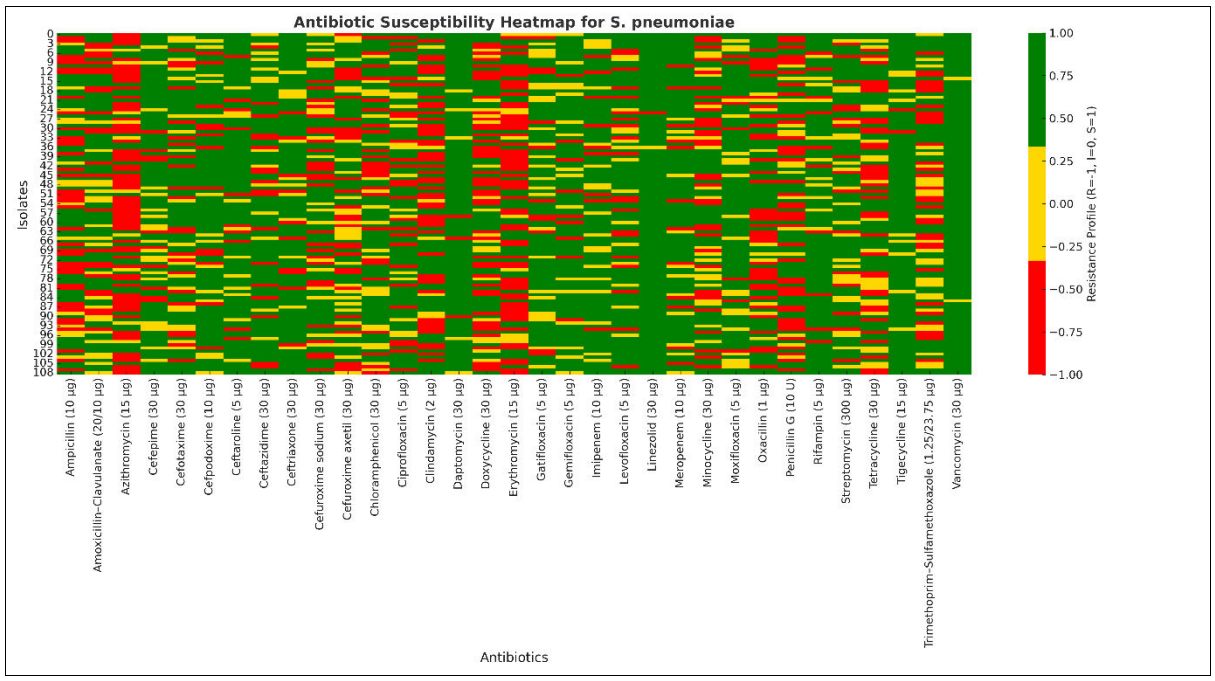

Table.2 Comparative Phenotypic and Biochemical Profiling of *S. pneumoniae* and non-*S. pneumoniae* isolates

Test / Characteristic	*S. pneumoniae* (n = 109)	Non-pneumococcal isolates (n = 41)
Gram reaction & morphology	Gram +, lancet-shaped diplococci	Gram +, cocci (chains/clusters)
Hemolysis on 5% SBA	Alpha-hemolysis (greenish)	Alpha or gamma hemolysis
Catalase test	Negative	Negative
Oxidase test	Negative	Negative
Optochin susceptibility	Sensitive (≥14 mm zone)	Resistant (≤9 mm zone)
Bile solubility	Positive (lysis observed)	Negative (no lysis)
Bacitracin susceptibility	Resistant	Variable
Glucose fermentation	Acid production (+)	Acid production (+)
Sucrose fermentation	Acid production (+)	Variable
Inulin fermentation	Acid production (+)	Negative
Lactose fermentation	Variable	Variable
Mannitol fermentation	Variable	Variable

The current study has proved the *Streptococcus pneumoniae* as a prime pathogen in hospitalized pneumonia sufferers in Beed, Maharashtra with the prevalence rate at 72.6 percent among the suspected isolates. This large figure affirms its dominant position in community-acquired and hospital-acquired pneumonia, and such is the case in patients internationally as pneumococcus is reported as the major cause of bacterial pneumonia among children and adults (File, 2004; Troeger *et al.,* 2018). Nevertheless, the rates in this study are higher than those recorded by national surveillance (20-43% isolation) (Rodgers & Klugman, 2015).

The difference is probably because of regional epidemiology, under-reporting in the rural areas, and it is possible to create variation in the coverage of vaccination, especially in Beed which is underrepresented in the pneumococcal surveillance. The distribution of isolates by the demographic data revealed a slight male predominance (56 %), which is also similar to the previous studies that show that men, particularly with comorbidities such as COPD or higher smoking levels, are more susceptible to severe pneumococcal infections (Lim, 2021). Nevertheless, the fact that the ratio between men and women remained relatively balanced in all wards, contributes evidence to the pathogen represented in a wide occupation group. Notably, the dominance of intensive care and respiratory wards isolates contributes to the clinical importance of pneumococcal pneumonia, consistent with the view that invasive pneumococcal disease is highly prevalent in acute care hospitals and has been found to cause extended hospital stay (Cheong & Song, 2024).

Phenotypic and biochemical identification of the isolates was done using the traditional methods which included Gram stain, haemolysis, susceptibility to optochin and bile solubility. Although these are low in cost and are predictable in resource-limited labs, they do not have the resolution that molecular assays and capsular typing would offer (Richter *et al.,* 2008).

Molecular types of serotyping like PCR typing or use of MALDI-TOF MS might have done better especially differentiating the closely related viridans streptococci. However, in semi-urban areas such as Beed where complex diagnostics are not readily available, pooling of samples on the basis of phenotypic tests would be feasible and indicative of the reality in the field. Antimicrobial susceptibility testing showed some worrying trends of resistance in relation to drugs. Resistance to penicillin and ampicillin was persistent with only 52.3% of isolates being susceptible with increasing incidences of resistance as seen in Indian and international studies since the advent of resistant strains of the penicillin in the 1960s (Taneja & Sharma, 2019). Comparable studies conducted in India show to 30% penicillin resistance (Veeraraghavan & Kurien, 2011), and the global surveys report resistance increasing between 30 and 50% (Naghavi *et al.,* 2024). The amplified resistance in Beed is probably due to excessive prescribing, over the counter access to antibiotics, and chronic absence of stewardship efforts (Feldman & Anderson, 2014). Third-generation cephalosporins are more efficacious, with a ceftriaxone and ceftazidime retaining more than 75-percent susceptibility as shown in Delhi and South India where ceftriaxone resistance is not

very high as that of penicillin (Chawla *et al.,* 2010). Cefotaxime was, however, observed to have diminished activity (61.5%), demonstrating intra-class differences. The success of more recent generation agents like cefepime (78 %) and ceftaroline (81.6 %) implies that they can still be depended upon, but their potential higher cost and limited availability in rural facilities may limit use. Most notably, cephalosporin resistance is commonly the result of modification in the penicillin-binding proteins, which are capable of becoming horizontally transferred increasing the potential of future intensification (Davies & Davies, 2010).

Resistance to macrolides was impressive, with the azithromycin susceptibility being 29.4% and clindamycin not being susceptible in 45% of the cases. This is in agreement with studies carried out in India that show approximately 40% resistance to erythromycin (Veeraraghavan & Kurien, 2011) and surveillance studies conducted worldwide that indicate the presence of macrolide resistance genes (*erm*B, *mef*A) as contributing factors (Rie Isozumi *et al.,* 2007). The current data opposes conclusively the use of macrolides as empirical therapy in Beed because of low efficacy and high potential of therapeutic failure. Fluoroquinolones were somewhat effective with levofloxacin showing better results than ciprofloxacin (71.6 vs 63.3), because they have more activity against pneumococcal (Chen *et al.,* 2019). However, resistance rates of 1322 are worrisome, especially in the context of increasing use of fluoroquinolones as first-line agents in pneumonia in adults. Misuse can stimulate resistance even more rapidly as witnessed in East Asia where the fluoroquinolone resistance grew rapidly due to the irrational usage of the medication (Sweileh, 2021).

Tetracyclines displayed inconsistent activity with minocycline being the most active tetracycline, but resistance was still significant. Full coverage (100%) of tigecycline is promising and in line with other studies that indicate its potential continued use against resistant strains of pneumococci (Yaghoubi *et al.,* 2021). Its application is, however, limited by the administration route (iv), being costly and toxic issues, limiting its application to only salvage therapies. Glycopeptides, including vancomycin, showed full activity and linezolid (98.2%) and daptomycin (92.7%) were very effective. These results are similar to the surveillance data worldwide on the maintenance of the efficacy of these last-line agents (File, 2006). However, development in dependence upon such drugs presents risks of developing resistance, as has been reported with vancomycin-resistant enterococci and has been noted occasionally in pneumococcus (Arias & Murray, 2012). Therefore, they must be limited in the case of confirmed multidrug-resistant cases only.

The efficacy of carbapenems (imipenem and meropenem) was also effective (>78%) in agreement with previously reported findings in India (Zhanel *et al.,* 1998). It is important to note however, that, in light of the growing worldwide concern of carbapenemase-producing bacteria, indiscriminate administration may quickly undermine their effectiveness (Bonomo *et al.,* 2018). Promising activity (81.6%) was observed with rifampin, however due to its inherent ability to select rapid resistance it is not a useful agent other than in combination regimens (Appelbaum, 2002). Low response to trimethoprim-sulfamethoxazole (43.1% susceptible) was anticipated because resistance rates in India have been reported to be high because of its overuse treating respiratory infections and prophylaxis in HIV programs (Chawla *et al.,* 2010). This points to the fact that it is not suited well in empirical treatment in pneumococcal pneumonia. Such results in the context of public health add weight to the twin issues of high pneumococcal prevalence and concerning antimicrobial resistance. This is a heavy burden on the economy: resistant pneumococcal infections have been estimated to cost the U.S. an impressive 1.5 billion dollars a year (Chen *et al.,* 2019), with uncontrolled antimicrobial resistance potentially costing the world global economy a hundred trillion dollars by 2050 (O Neill, 2016). Semi-urban districts which have high exposure to empirical treatment without culture such as in Beed are prone to adverse outcomes, extended hospital stay and death. Vaccination has always been a staple in the fight against pneumococcal. The introduction of PCV13 to India into its Universal Immunization Programme has lessened invasive illnesses of the pneumococcus (Kumar *et al.,* 2025). However, the heterogeneous vaccine coverage in Beed hinders its effectiveness and the poor serotype coverage of the vaccine requires that the circulation strains be monitored (Dhawale *et al.,* 2025). Serotype replacement has been observed elsewhere, in many cases with resistant clones, highlighting the importance of dynamic vaccine approaches even after PCV introduction (Gladstone *et al.,* 2017).

An important drawback of such a study is that it is based on phenotypic identification and not followed up with molecular confirmation and serotyping. It would be

important to include multilocus sequence typing (MLST) or whole-genome sequencing in order to trace resistant clones and obtain more information on genetic factors behind resistance (Larsen *et al.,* 2012). Nevertheless, in the circumstances of Beed with its limited resources, the employed phenotypic approach is feasible and delivers long overdue baseline information. To conclude, it can be seen that *S. pneumoniae* shows great prevalence amongst cases of pneumonia in Beed and has alarming penicillin, macrolides, clindamycin, tetracyclines, and cotrimoxazole resistance. The newer cephalosporins, carbapenems, tigecycline, vancomycin, and linezolid all have good efficacy, although their use as last-line therapies is of concern regarding sustainability. These data point to the necessity to increase antimicrobial stewardship, rational prescribing, microbiological confirmation prior to treatment, and broadened vaccination. In the absence of such processes, the semi-urban districts are threatened with subjugation of the double-edged curse of pneumococcal disease, and the growing resistance to it.

In conclusion, the study identifies *S. pneumoniae* as the most common pathogen in pneumonia patients admitted to the hospital in Beed, Maharashtra with very high prevalence of 72.6%, in addition to showing a dangerous resistance to various first line agents, such as penicillin, macrolides, clindamycin, tetracycline, and cotrimoxazole. Resistance is stable at levels that are susceptible to the newer cephalosporins, carbapenems, vancomycin, linezolid, and tigecycline levels, offers therapeutic reassurance but this resistance demonstrates that the use of these agents as a last resort choice should be subject to rational stewardship, culture driven-prescribing, and strict limitations on their use. As reflected in the findings, the urgency of aligning locally-applied treatment guidelines with local resistance patterns cannot be underestimated, neither can the overall public health need of increasing pneumococcal vaccination coverage in such semi-urban districts as Beed, which requires further efforts to enhance vaccine availability to unrepresented populations, combined with the improvement of diagnostic capacity in particularly under-privileged areas. Finally, unless there are timely efforts to intensify surveillance, maximize empirical treatment and optimize rational use of antimicrobials, pneumococcal infection would continue to contribute to populations at risks in terms of elevated morbidity, mortality, and economic burden- an issue that justifies this study as a timely demand in terms of ensuring health and policy interventions.

Authors Contributions

Vidya V. Jadhav: Investigation, analysis, writing original draft. K. V. Bartakke: Methodology, investigation, writing-reviewing.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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