



MICROBIOLOGICAL PROFILE AND ANTIMICROBIAL RESISTANCE PATTERNS IN CHRONIC SUPPURATIVE OTITIS MEDIA: A HOSPITAL-BASED STUDY

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ABSTRACT

Background: Chronic suppurative otitis media (CSOM) remains a major public health concern in low- and middle-income countries, contributing significantly to preventable hearing loss. The microbiological spectrum of CSOM and evolving antimicrobial resistance patterns vary across regions, making periodic surveillance essential for guiding effective treatment strategies.

Objective: To determine the microbiological profile and antimicrobial resistance patterns among patients with CSOM attending a tertiary care hospital in Udaipur, Rajasthan.

Methods: A hospital-based cross-sectional study was conducted from January 2025 to June 2025 among 150 clinically diagnosed CSOM patients. Middle ear discharge samples were collected aseptically after aural toilet and processed using standard microbiological procedures. Bacterial isolates were identified through Gram staining, culture characteristics, and biochemical tests. Antimicrobial susceptibility was assessed using the Kirby-Bauer disc diffusion method and interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Data were analyzed using SPSS version 25. Categorical variables were expressed as percentages, and associations were assessed using Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results: Positive bacterial culture was obtained in 143 cases (95.3%). A total of 151 isolates were recovered, with Gram-negative organisms predominating (65.6%). *Pseudomonas aeruginosa* was the most common isolate (39.7%), followed by *Staphylococcus aureus* (27.8%), *Klebsiella* spp. (11.9%), *Proteus* spp. (10.6%), and *Escherichia coli* (6.6%). Methicillin-resistant *S. aureus* (MRSA) accounted for 9.5% of *S. aureus* isolates. There was a significant association between CSOM type and bacterial distribution, with *P. aeruginosa* more common in atticointral disease ($p = 0.047$). High susceptibility

was observed with piperacillin-tazobactam, amikacin, ciprofloxacin, vancomycin, and linezolid, whereas resistance to beta-lactam antibiotics was frequent. Multidrug resistance was detected in 14.6% of isolates.

Conclusion: The study highlights *P. aeruginosa* and *S. aureus* as principal pathogens in CSOM, with emerging antimicrobial resistance patterns. Culture-based therapy and antibiotic stewardship are crucial to ensure effective management and prevent complications. Ongoing regional surveillance is recommended to optimize empirical therapy and improve patient outcomes.

Keywords: Chronic suppurative otitis media, microbiological profile, antimicrobial resistance, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, antibiogram, MDR.

INTRODUCTION

Chronic suppurative otitis media (CSOM) is a long-standing inflammatory condition of the middle ear characterized by persistent or recurrent ear discharge through a tympanic membrane perforation, often accompanied by varying degrees of hearing impairment. The World Health Organization (WHO) identifies CSOM as one of the most common causes of avoidable hearing disability, especially in low- and middle-income countries where socioeconomic and environmental risk factors are prevalent [1]. Globally, CSOM is estimated to affect millions of individuals, disproportionately impacting children and communities with limited access to healthcare, sanitation, and early treatment facilities [2]. A recent review emphasized that CSOM remains a preventable public health concern with serious long-term functional and social implications [3].

The burden of CSOM is particularly significant in resource-constrained regions, where delayed diagnosis, self-medication, and lack of specialized ENT services contribute to disease chronicity [4]. In many developing countries including India, CSOM prevalence exceeds the WHO threshold for high-risk communities, with reported rates often above 5% in rural populations [5]. Children represent the most vulnerable subgroup because persistent middle ear infection and untreated hearing loss may interfere with speech acquisition, cognitive development, academic performance, and social behavior, thereby affecting the overall quality of life and future productivity [4,5]. Adults with long-standing disease may also experience difficulties in communication, reduced work efficiency, and psychosocial stress.

Microbiological evaluation plays a critical role in understanding disease behavior and guiding therapy in CSOM. Studies consistently show that certain aerobic bacterial pathogens dominate the clinical isolates associated with CSOM. *Pseudomonas aeruginosa* and *Staphylococcus aureus* are the most frequently implicated organisms, followed by *Klebsiella* spp., *Proteus* spp., and *Escherichia coli* [6–8]. However, the prevalence of specific pathogens varies between regions, healthcare settings, and patient populations, making periodic surveillance essential. Anaerobes and fungi may also contribute to chronic infection, especially in recurrent or inadequately treated cases, although they are less frequently detected due to diagnostic limitations in many laboratories [6,8].

The growing challenge of antimicrobial resistance (AMR) in CSOM pathogens has emerged as a significant barrier to effective management. Multiple studies from tertiary care centers have reported increasing resistance to commonly prescribed antibiotics including ampicillin, amoxicillin-clavulanate, first- and second-generation cephalosporins, macrolides, and even previously reliable topical and systemic agents such as ciprofloxacin and gentamicin [7–9]. The emergence of multidrug-resistant (MDR) strains, extended-spectrum beta-lactamase (ESBL) producers, methicillin-resistant *Staphylococcus aureus* (MRSA), and resistant *P. aeruginosa* significantly complicates empirical treatment and increases the risk of persistent infection and complications [8–10]. Such treatment challenges also increase healthcare costs, duration of therapy, and likelihood of surgical intervention.

AMR in CSOM must additionally be viewed within the broader global resistance crisis. The WHO categorizes AMR among the most critical threats to global public health, noting that resistant infections increase morbidity, mortality, and strain on health systems [11]. A recent CDC report estimated that antimicrobial-resistant bacteria were responsible for millions of deaths globally, with misuse and overuse of antibiotics as major contributors [12]. In countries like India, where over-the-counter antibiotic access, repeated empirical prescribing, and incomplete treatment courses are common, selective pressure accelerates resistance trends [5,7].

Given the geographic variability of pathogens and resistance profiles, regular surveillance of microbiological patterns in CSOM is essential for effective case management. Such data help clinicians tailor empirical antibiotic therapy, improve treatment outcomes, reduce recurrence, and support antimicrobial stewardship [8–10]. Several Indian studies have highlighted the shifting microbial landscape and escalating resistance patterns, underscoring the importance of continuous local data generation [6–10]. However, patterns may differ across regions due to environmental exposure, community prescribing behavior, and population characteristics, necessitating region-specific research.

Therefore, the present hospital-based study was conducted at a tertiary care center in Udaipur, Rajasthan, to assess the microbiological spectrum and antimicrobial resistance patterns in patients with CSOM. This study contributes region-specific evidence to guide clinical decision-making, improve antimicrobial policy, and enhance management strategies for CSOM.

METHODOLOGY

Study Design and Setting: This was a hospital-based cross-sectional study conducted in the Department of Otorhinolaryngology of a tertiary care hospital in Udaipur, Rajasthan. The study was carried out over a period of six months, from January 2025 to June 2025.

Study Population: Patients attending the ENT outpatient department or admitted in wards with clinical features suggestive of CSOM were screened for eligibility. A total of 150 patients satisfying the inclusion criteria were selected by consecutive sampling.

Inclusion Criteria

- Patients of all genders aged ≥ 5 years diagnosed clinically with CSOM
- Presence of persistent or recurrent ear discharge through a perforated tympanic membrane for more than 6 weeks
- Willingness to participate and provide informed consent (and assent for minors, with parental consent)

Exclusion Criteria

- Patients with acute otitis media or otitis externa
- Patients who had received topical or systemic antibiotics within the preceding 7 days
- History of recent ear surgery
- Patients with suspected malignancy of the ear

Data Collection and Clinical Evaluation: Detailed demographic and clinical data including age, sex, residence, duration of symptoms, ear involvement (unilateral/bilateral), history of previous treatment, and presence of complications were recorded using a pre-designed proforma. Otoscopic or otoendoscopic examination was performed to confirm the diagnosis and classify CSOM into tubotympanic (safe) and atticotympanic (unsafe) types.

Sample Collection and Microbiological Processing: After proper aural toilet, middle ear discharge was collected aseptically using sterile cotton swabs, avoiding contact with the external auditory canal to prevent contamination. The specimens were immediately transported to the microbiology laboratory for processing.

Gram staining was performed for preliminary identification. Each sample was inoculated on Blood agar and MacConkey agar, and incubated aerobically at 37°C for 24–48 hours. Growth was identified by colony characteristics, Gram reaction, and standard biochemical tests. Where available, automated identification systems were also used for confirmation.

Antibiotic Susceptibility Testing: Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar. Interpretation of results was done according to the latest Clinical and Laboratory Standards Institute (CLSI) guidelines. Commonly tested antibiotics included aminoglycosides (gentamicin, amikacin), fluoroquinolones (ciprofloxacin, ofloxacin), beta-lactam antibiotics (amoxicillin–clavulanate, cefuroxime, ceftriaxone, piperacillin-tazobactam), and glycopeptides (vancomycin for Gram-positive isolates). Multidrug resistance (MDR) was defined as non-susceptibility to ≥ 3 antimicrobial classes.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics software (version 25). Categorical variables such as bacterial isolates and antimicrobial susceptibility patterns were presented as frequencies and percentages. Continuous variables like age and duration of symptoms were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), as appropriate. The association between bacterial isolates and clinical variables (such as type of CSOM) was evaluated using Chi-square test or Fisher's exact test. A p-value of <0.05 was considered statistically significant.

Ethical Considerations: This study was conducted following the ethical principles outlined in the Declaration of Helsinki. All participants were informed about the purpose, procedures, potential benefits, and minimal risks associated with the study. Written informed consent was obtained from adult participants and from parents or legal guardians of pediatric participants, with assent taken from children aged 7–18 years. Confidentiality and privacy of patient information were strictly maintained throughout the study. No financial burden was imposed on participants for laboratory procedures related to the study.

RESULTS

A total of 150 patients diagnosed with CSOM were included in the study. The mean age of participants was 26.4 ± 12.8 years (range: 5–62 years), with the highest proportion belonging to the 11–20-year age group (32.7%). There were 82 males (54.7%) and 68 females (45.3%), resulting in a male-to-female ratio of 1.2:1. Most participants belonged to rural areas (61.3%). The tubotympanic (safe) type of CSOM was seen in 105 cases (70%), while 45 patients (30%) had the atticointral (unsafe) type. Table 1 shows the demographic and clinical characteristics of study participants.

Table 1. Demographic and Clinical Profile of CSOM Patients (n = 150)		
Variable	Category	Frequency (%)
Age (years)	5–10	21 (14.0)
	11–20	49 (32.7)
	21–40	52 (34.7)
	>40	28 (18.6)
Gender	Male	82 (54.7)

Table 1. Demographic and Clinical Profile of CSOM Patients (n = 150)		
	Female	68 (45.3)
Residence	Rural	92 (61.3)
	Urban	58 (38.7)
CSOM Type	Tubotympanic	105 (70.0)
	Atticoantral	45 (30.0)

Of the 150 samples, 143 (95.3%) yielded positive bacterial growth, while 7 (4.7%) showed no growth. A total of 151 bacterial isolates were recovered, as some samples were polymicrobial. Gram-negative bacilli constituted 65.6%, while Gram-positive cocci accounted for 34.4% of isolates. The most frequently isolated organism was *Pseudomonas aeruginosa* (39.7%), followed by *Staphylococcus aureus* (27.8%), *Klebsiella* spp. (11.9%), *Proteus* spp. (10.6%), and *Escherichia coli* (6.6%). Methicillin-resistant *S. aureus* (MRSA) was detected in 4 isolates (9.5% of *S. aureus*). There was a statistically significant association between CSOM type and pathogen distribution, with *P. aeruginosa* showing higher prevalence in atticoantral disease ($\chi^2 = 6.12$, $p = 0.047$). Table 2 summarizes the microbial isolates and their distribution in CSOM types.

Table 2. Distribution of Bacterial Isolates and Association with CSOM Type (n = 151 isolates)			
Organism	Total (%)	Tubotympanic (n=102)	Atticoantral (n=49)
<i>Pseudomonas aeruginosa</i>	60 (39.7%)	35 (34.3%)	25 (51.0%)
<i>Staphylococcus aureus</i>	42 (27.8%)	32 (31.4%)	10 (20.4%)
<i>Klebsiella</i> spp.	18 (11.9%)	14 (13.7%)	4 (8.2%)
<i>Proteus</i> spp.	16 (10.6%)	12 (11.8%)	4 (8.2%)
<i>Escherichia coli</i>	10 (6.6%)	7 (6.9%)	3 (6.1%)
MRSA	4 (2.6%)	2 (1.9%)	2 (4.1%)

$\chi^2 = 6.12$, $df=2$, $p = 0.047$ (significant)

Antibiotic susceptibility patterns showed variation between Gram-negative and Gram-positive organisms. Among Gram-negative isolates, *P. aeruginosa* showed highest sensitivity to piperacillin-tazobactam (86.7%), amikacin (83.3%), and ciprofloxacin (78.3%). Lower sensitivity was observed to cefuroxime (38.3%) and amoxicillin-clavulanate (30.0%). For *S. aureus*, vancomycin (100%), linezolid (100%), and clindamycin (88.1%) demonstrated the highest susceptibility, while resistance to penicillin-class drugs exceeded 60%. Overall, multidrug resistance (MDR) was detected in 22 isolates (14.6%), predominantly among Gram-negative bacilli. Table 3 presents antimicrobial sensitivity trends.

Table 3. Antibiotic Susceptibility of Major CSOM Isolates (Percentage Sensitive)			
Antibiotic	<i>P. aeruginosa</i>	<i>S. aureus</i>	Enterobacterales (<i>Klebsiella</i> , <i>Proteus</i> , <i>E. coli</i>)
Amoxicillin-clavulanate	30.0%	42.8%	41.2%
Cefuroxime	38.3%	57.1%	52.9%

Table 3. Antibiotic Susceptibility of Major CSOM Isolates (Percentage Sensitive)

Ciprofloxacin	78.3%	73.8%	68.6%
Gentamicin	71.7%	66.7%	72.5%
Amikacin	83.3%	—	81.3%
Piperacillin-tazobactam	86.7%	—	79.0%
Vancomycin	—	100%	—
Linezolid	—	100%	—

DISCUSSION

The present hospital-based study evaluated the microbiological profile and antimicrobial susceptibility patterns among patients with chronic suppurative otitis media (CSOM) in a tertiary care setting in Udaipur. The findings demonstrated that CSOM remains predominantly associated with bacterial infection, with a culture positivity of 95.3%, which aligns with previous reports documenting yields between 85–98% [6–9]. This high positivity supports the understanding that CSOM is primarily a microbiological disease rather than purely inflammatory in etiology [3,5].

In the present study, *Pseudomonas aeruginosa* emerged as the most frequently isolated organism (39.7%), followed by *Staphylococcus aureus* (27.8%). This pattern is consistent with earlier studies from India and neighboring regions, where these two organisms continue to dominate CSOM microbiology [6–9]. The higher prevalence of *P. aeruginosa* in atticointral disease (51.0%) was statistically significant ($p=0.047$), suggesting increased virulence and invasive potential. Similar observations have been reported by Hiremath et al. [7] and Kombade et al. [8], who also documented a higher frequency of *P. aeruginosa* in unsafe CSOM. The organism's ability to form biofilms, resist phagocytosis, and survive in moist environments likely contributes to its persistence [13].

Staphylococcus aureus was the second most prevalent isolate (27.8%), comparable to reports from Bangladesh, Nigeria, and northern India [6–8,14]. Methicillin-resistant *S. aureus* (MRSA) was detected in 9.5% of *S. aureus* isolates, lower than the prevalence reported by Geeta et al. (15%) [9] and Mukhopadhyay et al. (18%) [10]. The lower MRSA proportion in this cohort may reflect improving infection-control practices or reduced empirical misuse of anti-staphylococcal antibiotics. Other Gram-negative organisms including *Klebsiella* spp., *Proteus* spp., and *Escherichia coli* accounted for 29.1% of isolates, consistent with previously reported ranges of 20–35% [6,8,14]. The presence of polymicrobial growth in a subset of cases further supports evidence that chronic ear infections may evolve into complex microbial ecosystems facilitated by biofilm formation [13,15].

The antimicrobial susceptibility analysis revealed important patterns relevant to clinical management. *P. aeruginosa* demonstrated highest sensitivity to piperacillin-tazobactam (86.7%), amikacin (83.3%), and ciprofloxacin (78.3%). These findings align with prior Indian studies demonstrating sustained susceptibility to antipseudomonal agents [7–9]. However, declining susceptibility to older cephalosporins and aminopenicillins is evident, reflecting known trends in antimicrobial resistance [11,12]. This observation reinforces WHO recommendations emphasizing stewardship to preserve efficacy of higher-generation antimicrobials [11].

Staphylococcus aureus showed complete susceptibility to vancomycin and linezolid, while β -lactam resistance exceeded 60%, a trend consistent with previous regional studies [8–10,14]. The observed resistance pattern may be attributed to easy over-the-counter access to antibiotics, self-medication, and incomplete treatment courses, which are known contributors to antimicrobial resistance in India [5,11,12].

The overall multidrug-resistant (MDR) rate of 14.6% in the present study falls within the moderate range reported in Indian and global studies (10–32%) [8,14,15]. Although not alarmingly high, this trend warrants ongoing surveillance because CSOM patients often require repeated antibiotic therapy, increasing the opportunity for resistance development. Biofilm-associated chronicity further complicates eradication of MDR organisms [13,15].

Comparison with other published literature indicates that while the microbial pattern remains largely stable over time, antimicrobial sensitivity patterns are evolving, particularly among Gram-negative pathogens. This emphasizes the importance of periodic local antibiogram updates to guide empirical treatment, as reliance on outdated resistance patterns may result in therapeutic failure and progression to complications [3,10,14].

A key strength of this study is the standardized methodology and adequate sample size, enabling meaningful comparison with earlier regional and national studies. However, certain limitations must be acknowledged. Anaerobic cultures and fungal isolates were not included, potentially underestimating the full microbial burden. Additionally, antibiotic susceptibility testing relied on conventional disc diffusion; molecular detection of resistance genes such as ESBL or MRSA markers was not performed.

The findings underscore the need for rational antibiotic use and adherence to culture-guided therapy wherever feasible. Topical antibiotics with narrower spectra, oral antibiotics reserved for systemic features, and avoidance of prolonged empirical therapy are in line with recommended stewardship guidelines [11–12]. Education of patients regarding treatment compliance may further reduce recurrence and resistance.

CONCLUSION

The present study provides valuable insight into the microbiological pattern and antimicrobial resistance in patients with chronic suppurative otitis media in a tertiary care setting in Udaipur. The findings reaffirm that *Pseudomonas aeruginosa* and *Staphylococcus aureus* remain the predominant pathogens, consistent with regional and global trends. Antimicrobial susceptibility testing demonstrated good sensitivity to piperacillin-tazobactam, amikacin, ciprofloxacin, vancomycin, and linezolid, while resistance to commonly prescribed beta-lactam antibiotics was notably high. The presence of multidrug-resistant isolates, though moderate, highlights the need for continuous monitoring and rational antibiotic use. The observed association between organism type and clinical form of CSOM further emphasizes the role of evidence-based therapy. Regular surveillance, culture-guided treatment, and antibiotic stewardship are essential to ensure effective management and prevent complications. These findings contribute to regional epidemiological data and may help guide clinicians in selecting appropriate empirical treatment strategies for CSOM.

Declarations

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