REVIEW ARTICLE

Comparative Studies of the Effect of Antibiotics in the Management of Otitis Media in Children

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Abstract

In clinical practice, otitis media continues to be a leading cause of antibiotic prescriptions and is one of the most prevalent infectious illnesses in the world, especially in children. The disease includes a variety of conditions with varying etiologies and treatments, such as acute otitis media (AOM), otitis media with effusion (OME), and chronic suppurative otitis media (CSOM). Antibiotics continue to be the mainstay of treatment, but their overuse and incorrect use have generated antimicrobial resistance, decreasing treatment efficacy and complicating illness outcomes This review addresses the current information on otitis media in children, with a focus on comparative effectiveness, antibiotic selection, and new developments in resistance. It emphasizes the need for sensible antibiotic usage and the incorporation of preventive strategies like vaccination and antibiotic stewardship, while also highlighting evidence-based treatment recommendations from international guidelines. Long-term therapeutic results could be improved by future approaches that emphasize innovative antibacterial development, resistance monitoring, and diagnostic precision. This review attempts to encourage better knowledge, accountability, and efficient treatment of otitis media in both pediatric and adult populations by combining the most recent data on antibiotic efficacy and resistance.

Keywords: Streptococcus pneumoniae • antibiotic selection • antibiotic resistance • amoxicillin • pediatric infections • otitis media in children • acute otitis media • antimicrobial stewardship

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Introduction

One of the most common infections detected globally, especially in children, is otitis media. This term represents middle ear inflammation, which can manifest as acute otitis media (AOM), chronic suppurative otitis media (CSOM), or otitis media with effusion (OME. The causes, severity, and methods of therapy vary for each form. The symptoms of acute otitis media, which frequently follow an upper respiratory tract infection, include fever, agitation, and earache that appear quickly [1]. In contrast to chronic suppurative otitis media, which is characterized by a persistent or recurring infection with tympanic membrane rupture and continuous ear discharge, otitis media with effusion includes the development of fluid in the middle part of the ear without an acute infection [2].

Otitis media continues to be a major global public health concern, especially for children under five, resulting in several physician visits and prescriptions for antibiotics each year. Due to inadequate vaccination rates, frequent upper respiratory infections, and limited access to treatment, the illness burden is significantly higher in developing nations. Moraxella catarrhalis, Haemophilus influenzae, and Streptococcus pneumoniae are the most frequent bacterial infections linked to otitis media. Staphylococcus aureus and Pseudomonas aeruginosa are also commonly isolated in chronic and recurring cases. Antibiotic therapy is essential for managing such infections because a majority of them have bacterial etiologies, particularly when there is a risk of complications or systemic symptoms [3].

However, antibiotic abuse and excess use in otitis media have grown to be serious global issues. Common infections are becoming increasingly resistant to antibiotics as a result of inappropriate prescriptions, insufficient treatment regimens, and empirical use without performing a culture sensitivity test. In addition to decreasing therapeutic efficacy, this enhances the risk of repeated infections as well as therapy expenses. Therefore, choosing antibiotics logically and with evidence is essential to ensuring therapeutic efficacy and preventing the emergence of resistance [4].

The objective of this review paper is to examine and contrast the widely used antibiotics for the treatment of otitis media, with an emphasis on their mechanisms, effectiveness, resistance patterns, and suitable clinical grounds. Through an assessment of existing therapeutic

choices and the identification of the best agents for different types of otitis media, this paper seeks to help doctors utilise antibiotics more wisely and rationally.

Pathophysiology and Etiology of Otitis Media

The complex interactions between pathogens, host factors, and external factors lead to the development of otitis media. The Eustachian tube, which connects the middle ear to the nasopharynx, is ordinarily a sterile, air-filled hollow. This tube helps in middle ear discharge drainage and pressure equalisation. The middle ear experiences negative pressure and fluid accumulation when its function is compromised, which often comes on due to allergic reactions, upper respiratory tract infections, or structural abnormalities. This creates an environment that is conducive to microbial colonisation and infection [5].

Infectious Agents

Pathogenic bacteria are the main cause of otitis media, while viral infections frequently precede and help bacterial invasion. Moraxella catarrhalis, Streptococcus pneumoniae, and non-typeable forms of Haemophilus influenzae are the microorganisms most commonly linked to acute otitis media (AOM). During or after viral infections, these organisms, which typically live in the upper respiratory system, might climb to the middle ear through the Eustachian tube [6].

The pathogen spectrum changes in chronic suppurative otitis media (CSOM), favoring aggressive as well as resistant organisms, including Pseudomonas aeruginosa, Staphylococcus aureus, and, infrequently, Proteus or Klebsiella species. These bacteria frequently live in biofilms and cause chronic or recurring infections that are hard to treat with conventional antibiotics. Less frequently, viral agents like the influenza virus, adenovirus, and respiratory syncytial virus (RSV) can potentially contribute by either directly causing inflammation of the Eustachian tube or by making the mucosa more vulnerable to secondary bacterial infections [7].

Mechanisms of Pathophysiology

The pathophysiology of otitis media usually starts with a malfunction of the Eustachian tube. Young children are more susceptible to infection because their tubes are shorter, horizontal, and more easily blocked. Edema of the nasopharyngeal mucosa, which results from viral upper respiratory infections or allergic inflammation, can obstruct and accumulate sterile fluid in the middle ear. Bacterial development and eventual infection are facilitated by this effusion.

Following their entry into the middle ear, microorganisms cause an inflammatory reaction that results in purulent fluid buildup, mucosal edema, and increased vascular permeability. Otorrhea can develop from the pressure behind the tympanic membrane, which produces pain, bulging, and occasionally rupture. As shown in CSOM, recurrent infections or insufficient care might result in tympanic membrane perforation, structural damage, and persistent inflammation. Children with OME may still experience hearing loss and delayed acquisition of language due to chronic effusions, even in the absence of an active infection [8].

Environmental and Host Factors

Otitis media develops and persists due to several predisposing conditions. These include young children, bottle-feeding while supine, day-care attendance, being around tobacco smoke, having allergic rhinitis, and not having received an influenza or pneumococcal immunization. Susceptibility is also increased by genetic factors and anatomical differences, such as craniofacial deformities or cleft palate. The natural nasopharyngeal flora can be further altered by repeated antibiotic exposure, which encourages the choice of resistant microbial strains [9].

Antibiotic Therapy in Otitis Media

Antibiotic treatment continues to be the primary course of treatment for bacterial otitis media, although the kind and degree of the infection determine whether it is necessary and which is best. When deciding whether to start antibiotics, one must consider the possibility of bacterial etiology, the fact that many instances resolve on their own, and the increasing concern about antibiotic resistance. Although minor infections, especially in older children, may go away on their own, antibiotics are necessary when there are systemic symptoms, excruciating pain, or a chance of consequences like mastoiditis or hearing loss [10].

First-Line Antibiotics

Most worldwide guidelines still recommend amoxicillin as the first-line antibiotic for acute otitis media (AOM) because of its great safety, effectiveness, palatability, and affordability. It is highly effective against the three bacteria responsible for most AOM cases: Moraxella catarrhalis, Haemophilus influenzae, and Streptococcus pneumoniae. To deal with resistant strains of S. pneumoniae, high-dose regimens are frequently advised.

Amoxicillin–clavulanate is the recommended second option for patients who do not react to the first course of

treatment. The inclusion of clavulanic acid broadens its range of action against bacteria that produce β-lactamases, especially resistant M. catarrhalis and H. influenzae. Depending on age and clinical severity, therapy typically lasts five to ten days [11].

Alternative Agents and Second-Line Agents

In cases where β-lactam therapy is not appropriate or does not work, second-generation cephalosporins like cefuroxime and cefdinir are good options. When given parenterally, ceftriaxone works very well for individuals who cannot take oral treatment or for severe or recurring instances of AOM.

Azithromycin and clarithromycin are macrolides that provide good coverage against atypical pathogens and are used for people allergic to penicillins. But rather than being used as a regular treatment, S. pneumoniae and H. influenzae resistance restricts their usage to certain instances [12].

Since Pseudomonas aeruginosa and Staphylococcus aureus are the most common pathogens in chronic suppurative otitis media (CSOM), fluoroquinolones, especially topical ciprofloxacin or ofloxacin ear drops, are recommended. These substances limit systemic negative effects while achieving higher localized concentrations. Infections that are complex or resistant to treatment are often treated with systemic fluoroquinolones [13].

Administration Time and Route

Antibiotic treatment duration differs according to response, age, and the degree of illness. For children younger than two years or those with severe illness, a 10-day treatment is usually advised; however, for older children and adults with mild to moderate infections, shorter courses of five to seven days may be adequate. While intravenous or intramuscular methods have been designated for severe, noncompliant, or vomiting patients, oral medication is sufficient in the majority of situations [7].

Clinical Considerations and Reasonable Use

Antibiotic misuse is still a global concern, even if their benefits in certain situations have been demonstrated. Resistance development is facilitated by inadequate courses, incorrect prescriptions, and empirical use without microbiological verification. Therefore, in moderate or unclear instances, clinicians are advised to use a "watchful waiting" strategy in conjunction with appropriate analgesics and subsequent follow-up visits. Clinical effectiveness and long-term antimicrobial management are guaranteed by cautious selection of antibiotics according to the history of the patient, regional resistance patterns, and medication safety profiles [14].

A Comparative Analysis of Antibiotics

A thorough evaluation of the various drugs' efficacy, microbial coverage, resistance profiles, comfort, and pricing is necessary to choose the best antibiotic treatment for otitis media. Multiple research investigations and modifications to guidelines over the past 20 years have highlighted the fact that no single antibiotic is appropriate for every patient; instead, the selection should be based on the type of infection, the patient's characteristics, and local patterns in resistance [5].

Comparative Effectiveness and Spectrum of Activity

Amoxicillin is one of the most dependable and successful therapies for acute otitis media (AOM) among all available medications. It exhibits good efficacy against H. influenzae and M. catarrhalis and offers outstanding coverage against Streptococcus pneumoniae, the most frequent cause of bacterial infections. However, in some areas, the rise of bacteria that produce β-lactamase has somewhat decreased its efficacy. By blocking β-lactamase enzymes, amoxicillin-clavulanate provides enhanced effectiveness in these situations, extending its effectiveness to resistant strains of M. catarrhalis and H. influenzae.

Amoxicillin–clavulanate and cephalosporins, including cefuroxime, cefdinir, and ceftriaxone, have similar clinical efficacy rates. Ceftriaxone is very useful for severe infections, noncompliance, or therapy failure because of its exceptional bactericidal activity. Its convenience for outpatient use is, however, limited by its parenteral route [15].

Although macrolides, such as clarithromycin and azithromycin, are well tolerated and offer more comprehensive protection against atypical bacteria, their overall efficacy is reduced by the growing resistance of S. pneumoniae and H. influenzae. For patients with actual penicillin hypersensitivity, they continue to be the recommended choice. Fluoroquinolones, including ciprofloxacin or ofloxacin, are the preferred medications for treating chronic suppurative otitis media (CSOM) because of their strong anti-Straphylococcus aureus and anti-Pseudomonas aeruginosa properties. Topical preparations decrease systemic exposure, facilitate quicker infection resolution, and produce higher localized concentrations [14].

Table 1. Antibiotics Used in Otitis Media

Drug Class	Antibiotic	Target Pathogens	Level of Resistance	Preferred Use	Side Effect
β-lactam	Amoxicillin	S. pneumoniae, H. influenzae	Moderate Level	First-line of treatment for acute otitis media.	GI upset, rash
β-lactam + inhibitor	Amoxicillin–Clavulanate	β-lactamase producers	Low Level	Recurrent or resistant AOM	Diarrhea, nausea
Cephalosporin (3rd gen)	Ceftriaxone	Broad spectrum	Low Level	Severe/non-responsive AOM	Injection pain
Macrolide	Azithromycin	Atypical & Gram-positive bacteria	High Level	Penicillin allergy	GI upset, QT prolongation
Lincosamide	Clindamycin	Resistant S. pneumoniae, MRSA	Moderate Level	Refractory infections	GI upset, C. difficile risk
Fluoroquinolone	Ciprofloxacin (Topical)	Pseudomonas, S. aureus	Low Level	CSOM, otorrhea	Local irritation

Resistance Patterns and Treatment Difficulties

Prescription strategies for otitis media have been greatly impacted by the rise in antibiotic resistance. In certain areas, the development of β-lactamase by H. influenzae and M. catarrhalis has reduced the effectiveness of standard-dose amoxicillin, leading to suggestions for the use of amoxicillin–clavulanate or high-dose regimens. Similar to this, worldwide surveillance studies show that S. pneumoniae are becoming more resistant to macrolides, which reduces the effectiveness of azithromycin as a first-line treatment. Although topical fluoroquinolone resistance is still very low, cautious use is recommended to avoid the possibility of future resistance [16].

Finding a balance between cost, safety, and efficacy is another difficulty. Despite providing superior antibacterial coverage, cephalosporins and fluoroquinolones are more costly and, if administered carelessly, may encourage broad-spectrum resistance. As a result, they need to be used only in situations where first-line treatment is ineffective or when certain pathogens are suspected [17].

Clinical Choice and Decision-Making

Amoxicillin continues to be the gold standard for simple AOM based on comparative review because of its great efficacy, affordability, and safety. While macrolides are only advised for people with penicillin allergies, amoxicillin–clavulanate or cephalosporins are advised for recurrent or resistant instances. Topical fluoroquinolones continue to be the recommended treatment for persistent and chronic infections like CSOM. The prudent use of antibiotics—prescription of the most effective, narrow-spectrum medication for the shortest amount of time—should always be the driving concept [15].

Trends of Antibiotic Resistance in Otitis Media

In treatments of otitis media, antibiotic resistance has emerged as a significant worldwide concern that has a substantial impact on clinical outcomes and therapeutic success. The selection of resistant bacterial strains that are no longer responsive to traditional first-line medicines is a result of the extensive and frequently improper use of antibiotics, particularly in pediatric populations. This increasing resistance makes management choices more difficult and emphasizes the value of sensible prescription practices and ongoing monitoring of regional resistance trends [17].

Worldwide Assessment of Resistance Trends

Key otitis media infections have shown an obvious rise in resistance in recent years, according to research conducted in various countries. Due to changes in penicillin-binding proteins, Streptococcus pneumoniae, which was previously extremely sensitive to penicillin and amoxicillin, now exhibits variable degrees of resistance. Up to 30–40% of isolates in some regions show decreased sensitivity to β-lactam antibiotics, requiring the administration of greater dosages or other drugs [18].

Similar to this, Moraxella catarrhalis and Haemophilus influenzae both have significantly increased their capacity to produce β-lactamases, which reduces the effectiveness of conventional amoxicillin treatment. Although resistance is gradually growing even in these drugs, these strains are still vulnerable to β-lactam/β-lactamase inhibitor combos like amoxicillin–clavulanate [16].

Pseudomonas aeruginosa and Staphylococcus aureus have demonstrated significant resistance to several antibiotic classes, especially aminoglycosides and earlier

fluoroquinolones, in cases of chronic suppurative otitis media (CSOM). Treatment becomes even more difficult when methicillin-resistant S. aureus (MRSA) appears in ear infections since it involves the use of topical or stronger medications [18].

Reasons for Growing Resistance

Antibiotic resistance has increased due to a variety of factors. The prevalence of over-the-counter antibiotics in certain locations, pressure from parents on children to take antibiotics, inadequate treatment courses, and overprescription for viral upper respiratory infections all result in selective pressure on bacterial populations. Furthermore, resistance development is accelerated when broad-spectrum antibiotics are empirically used without sensitivity or culture testing.

Because children frequently get several antibiotic courses over brief periods of time, bacteria have numerous opportunities to adapt, which contributes to the frequent recurrence of otitis media. In environments with limited resources, resistance is further exacerbated by poor or fake drugs and insufficient dosage [19].

Clinical Management Implications

Poor clinical efficacy, failure of therapy, longer symptoms, and an elevated risk of consequences like mastoiditis or hearing impairment are the practical effects of antibiotic resistance in otitis media. The use of costly, broader-spectrum antibiotics, which may have more adverse effects and fuel broader antimicrobial resistance in the community, is also fueled by resistance.

Therefore, clinicians are recommended to use updated local resistance data in addition to empirical expertise when making therapeutic recommendations. To guarantee that first-line treatments continue to be effective, regular microbiological surveillance and antibiotic stewardship initiatives are crucial [14].

Techniques for Controlling Resistance

An interdisciplinary strategy is required to stop the growth of resistance. The foundation of resistance prevention is prudent antibiotic prescribing, which involves only taking antibiotics when a high suspicion that the illness is caused by bacteria. Since many infections heal on their own, several international guidelines support the idea of "watchful waiting" for mild or unclear instances of acute otitis media.

Vaccination is also an important prophylactic measure. In many nations, illnesses brought on by resistant S. pneumoniae strains have dramatically decreased since the introduction of the pneumococcal conjugate vaccine (PCV). Important elements of resistance control include teaching parents about the risks of self-medication, the natural progression of otitis media, and the significance of finishing recommended antibiotic treatments.

Long-term alternatives to treating recurring or resistant infections may come from ongoing research into novel antimicrobial drugs, combination therapy, and non-antibiotic strategies (such as probiotics or immunomodulators) [20].

Clinical Guidelines for the Treatment of Otitis Media with Antibiotics

A key component of managing otitis media (OM) effectively is the prudent use of antibiotics. Using antibiotics correctly guarantees a speedy recovery, avoids problems, and slows the spread of antibiotic resistance. The use of antibiotics should be guided by the clinical condition, individual's age, and regional bacterial resistance trends, according to worldwide guidelines from the World Health Organization (WHO), the American Academy of Pediatrics (AAP), and the National Institute for Health and Care Excellence (NICE) [21].

The main contributory factor of acute otitis media (AOM) is bacterial infection, while viral infections can also play a role. Patients with severe symptoms, such as acute ear discomfort, a high fever, or noticeable agitation, as well as children under two years old or those with weakened immune systems, are the primary candidates for antibiotics. Since spontaneous resolution frequently happens, many guidelines recommend a "watchful waiting" strategy for 48 to 72 hours in moderate or unclear instances. Amoxicillin continues to be the first-line option when antibiotic therapy is necessary because of its excellent pharmacokinetics, affordable price, safety, and high efficacy. To effectively cover against Streptococcus pneumoniae, a daily dose of 80–90 mg/kg in divided doses is usually advised. Amoxicillin–clavulanate is recommended if symptoms do not go away within 72 hours or if an infection with β-lactamase-producing organisms, like Moraxella catarrhalis or Haemophilus influenzae, is suspected. Alternatives like cefdinir, cefpodoxime, or azithromycin may be tried for people allergic to penicillin; nevertheless, macrolide resistance has grown to be more dangerous. Treatment typically lasts five to seven days for minor infections or older children, and 10 days for serious infections or younger children [22].

In contrast to AOM, otitis media with effusion (OME) is characterized by middle ear fluid buildup that is not caused

by an active infection. Since the majority of cases resolve without pharmacologic intervention, antibiotic therapy is typically not necessary. The mainstay of management is observation and audiologic follow-up to check for speech delay or hearing loss. Only when the effusion lasts more than three months or results in severe hearing loss may short antibiotic courses be warranted; even in these situations, the advantages are still modest and must be balanced against the possibility of resistance [19].

On the other hand, persistent otorrhea and a long-term infection with tympanic membrane perforation are hallmarks of chronic suppurative otitis media (CSOM). Staphylococcus aureus and Pseudomonas aeruginosa are two common resistant bacteria that are less sensitive to common systemic medicines. Because topical antibiotic therapy minimizes systemic side effects while providing high local concentrations at the infection site, it is the recommended strategy. Because of its strong antipseudomonal action and minimal ototoxic risk, ciprofloxacin or ofloxacin ear drops are most frequently prescribed. Oral ciprofloxacin systemic therapy may be employed in severe or refractory cases; ideally, this will be determined by the results of sensitivity and culture tests. However, unless clinically necessary, prolonged or recurrent use of antibiotics should be avoided [5].

Symptomatic treatment is still a crucial adjunct to antibiotic therapy. Analgesics, including ibuprofen or paracetamol, help patients feel more comfortable by reducing temperature and ear pain. However, the use of antihistamines and decongestants has not consistently shown any benefits and is typically discouraged. Tympanostomy tube insertion is one surgical procedure that may be explored in situations that are recurrent or resistant to therapy in order to decrease the frequency of infections and minimize the need for repeated antibiotic exposure [16].

Overall, preventing antibiotic misuse and effectively eliminating microorganisms are key components of clinical therapy for otitis media. For acute infections, amoxicillin remains the mainstay of treatment; for persistent infections, topical fluoroquinolones are preferred. To guarantee logical, secure, and efficient antibiotic treatment, clinicians must rely on evidence-based guidelines, local resistance monitoring, and patient-specific factors.

Table 2. Summary of Recommended Antibiotics in Different Types of Otitis Media

Type of Otitis Media	First-line Treatment	Alternatives Treatment	Route of Administration	Duration of Therapy
Acute OM	Amoxicillin	Amoxicillin–Clavulanate, Cefdinir, Azithromycin	Oral	5–10 days
OME	Observation	Amoxicillin (if persistent >3 months)	Oral	Short course
CSOM	Ciprofloxacin (ear drops)	Ofloxacin drops, oral ciprofloxacin	Topical ± Oral	7–14 days

Conclusion

Otitis media's high incidence, difficulty in diagnosing, and potential for consequences make it a major worldwide health concern, especially for children. Antibiotics have changed the course of disease, but their abuse is accelerating antimicrobial resistance and jeopardizing the effectiveness of long-term treatment. In addition to choosing antibiotics as efficiently as possible, the future of otitis media therapy also depends on combining precision-based and preventive measures. Increased vaccine coverage has already shown significant declines in infection rates and resistance patterns, especially against Streptococcus pneumoniae and Haemophilus influenza [4].

The development of clinical diagnostics and antibiotic stewardship to more precisely distinguish bacterial from viral illnesses is equally crucial. New studies on biofilm breakdown, host immunological modulation, and innovative antimicrobial drugs offer promising substitutes for resistant or recurring instances. To ensure the efficient and long-lasting treatment of otitis media in the coming decades, a shift toward evidence-based, customised, and preventive care—backed by global tracking of resistance patterns—will be necessary [23].

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