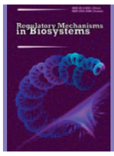

Regulatory Mechanisms in Biosystems

ISSN 2519-8521 (Print)
ISSN 2520-2588 (Online)
Regul. Mech. Biosyst.

Bacterial strains isolated from sinusitis infections and their drug resistance profiles in Nasiriyah (Iraq)

A. W. Malik*, S. M. Mohsen*, A. K. Mohsen**, S. Q. Mohammad***, O. A. Mohsein****

** Middle Technical University, Baquba Technical College, Diyala, Iraq*
*** Diyala University, Al-Muqdad College of Education, Diyala, Iraq*
**** Middle Technical University, Technical Institute – Baqubah, Diyala, Iraq*
***** Mazaya University College, Department of Medical Laboratory Techniques, Thi-Qar, Iraq*
***** Thi-Qar Health Directorate, Al Habbobi Teaching Hospital, Thi-Qar, Iraq*

Article info

Received 01.02.2025
Received in revised form 02.03.2025
Accepted 19.04.2025

Middle Technical University, Baqubah City, Diyala, 32001, Iraq. Tel.: +964-770-345-73-76. E-mail: anaswisam@mtu.edu.iq

Diyala University, Baqubah City, 32001, Diyala, Iraq. Tel.: +964-771-101-36-15. E-mail: abdallahm@uodiyala.edu.iq

Mazaya University, Thi-Qar City, 64001, Thi-Qar, Iraq. Tel.: +964-780-686-42-95. E-mail: osamaakram889@gmail.com

Malik, A. W., Mohsen, S. M., Mohsen, A. K., Mohammad, S. Q., & Mohsein, O. A. (2025). Bacterial strains isolated from sinusitis infections and their drug resistance profiles in Nasiriyah (Iraq). Regulatory Mechanisms in Biosystems, 16(2), e25049. doi:10.15421/0225049

Sinusitis, which is also referred to as rhinosinusitis, is one of the most prevalent causes of clinical visits in the United States. It is also one of the primary reasons why antibiotics are prescribed. This study aimed to identify the types of bacteria that cause sinusitis and find out the most effective types of antibiotics to optimise the success of treatment. Samples were collected with a sterile swab, which was gently inserted into the nasal cavity, then directed towards the sinus area. They were grown on nutrient media such as blood agar, MacConkey agar and Mueller-Hinton agar. Gram stain technology was used to identify bacteria such as *Staphylococcus* sp., *Streptococcus* sp., *Haemophilus influenzae*, *Moraxella catarrhalis*, biochemical tests were carried out, including catalase, oxidase, carbohydrate fermentation, and API (analytical profile index) test strips were used. The sensitivity of bacteria to antibiotics was examined using CLSI standards to ensure the accuracy of the results by culturing the bacteria on Mueller Hinton agar medium and placing the antibiotic disks. The results were recorded for sensitivity, intermediate sensitivity and resistance. Zone diameter measurements were taken to determine the effectiveness of the antibiotics. The results showed that the percentage of positive cases for *H. influenzae* was 36.7%, *Moraxella catarrhalis* 24.7%, *S. aureus* 16.0%, *S. pneumoniae* 15.3%, and *Staphylococcus epidermidis* 8.0%. *H. influenzae* showed full sensitivity to ceftriaxone, gentamycin, and vancomycin, while *Moraxella catarrhalis* was fully sensitive to ceftriaxone, imipenem, vancomycin, and oxacillin. *S. aureus* was sensitive to ceftriaxone, imipenem, gentamycin, vancomycin, and erythromycin. *S. pneumoniae* showed sensitivity to penicillin, gentamycin, and vancomycin. *S. epidermidis* was sensitive to gentamycin, nitrofurantoin, and erythromycin. The study concluded that the bacteria *H. influenzae* and *Moraxella catarrhalis* were the most common in sinusitis, with high sensitivity to common antibiotics such as ceftriaxone and gentamycin. This indicates the effectiveness of these antibiotics in treatment, which helps guide appropriate treatment and reduce bacterial resistance.

Keywords: rhinosinusitis; antibiotic resistance; *Escherichia coli*; *Haemophilus influenza*; *Streptococcus pneumoniae*; electrophoresis; PCR technique.

Introduction

Acute sinusitis refers to a bacterial infection in the sinuses. The more appropriate word is rhinosinusitis, as the sinus passages are connected to the nasal passages. Prescriptions for antibiotics typically originate from this source in both the United States and worldwide. Clearly defined treatment strategies for this common diagnosis are crucial in light of current guidelines and concerns regarding antibiotic resistance and the appropriate use of antibiotics (Mohammad et al., 2024; Furkatov et al., 2025). Viral infections are the most common cause of acute rhinosinusitis. Viral rhinosinusitis (VRS) is mostly caused by rhinovirus, adenovirus, influenza virus, and parainfluenza virus. *S. pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis* are the predominant pathogens responsible for acute bacterial rhinosinusitis (ABRS), with occurrence rates of 38%, 36%, and 16% respectively (Chow et al., 2012; Min et al., 2025). While fungal infections are uncommon, they primarily impact individuals with weakened immune systems, such as those with uncontrolled diabetes, HIV, cancer patients undergoing treatment, or individuals taking immunosuppressants for organ transplantation or rheumatologic conditions. It is worth noting that fungal infections can also lead to acute rhinosinusitis. Some of the common species include *Aspergillus*, *Rhizopus*, *Mucor*, and *Rhizomucor*.

It is crucial to distinguish between allergic fungal sinusitis (AFS), which occurs in individuals without weakened immune systems and manifests as a mass-like growth in a sinus canal, typically causing persistent symptoms, and acute invasive fungal sinusitis (IFS), which affects immunocompromised patients. While AFS will be referenced in other settings, the constraints of space restrict its inclusion in this specific work (Bahethi et al., 2024; Essa et al., 2024). Acute rhinosinusitis accounts for 20% of antibiotic prescriptions in humans. This places it as the eighth most prevalent cause for medication usage. Approximately 6% to 7% of children with respiratory issues get acute rhinosinusitis. Annually, approximately 16% of individuals receive a diagnosis of acute bacterial rhinosinusitis (ABRS). Due to the manner in which this clinical report is constructed, there is a possibility that the provided number is too elevated. The likelihood of viral rhinosinusitis (VRS) progressing into a bacterial infection in adults ranges from 0.5% to 2%. Among children, this occurrence has a frequency of 5% to 10% (Rosenfeld, 2016).

Rhinosinusitis occurs when the sinuses and nasal passageways are unable to effectively eliminate these antigens, leading to an inflammatory illness. The condition often manifests through three primary mechanisms: increased viscosity of sinus fluids (as observed in cystic fibrosis), impaired ciliary function (as seen in Kartagener syndrome), or obstruction of sinus openings due to structural factors such as a tumour or septal deviation. The temporary blockage of outflow areas typically occurs due to inflammation in the region produced by upper respiratory tract infections (URI) or nasal allergies, both of which result in rhinosinusitis. Under these circumstances, bacteria have the ability to enter the typically sterile paranasal airways, establish themselves, and proliferate. The spread of a sinus infection to adjacent areas such as the brain and orbit through the valveless diploic veins can have severe consequences. The cranial layer of the inner cancellous bone contains lines (Liva et al., 2021; Sato et al., 2021). The sinuses are lined with ciliated pseudostratified columnar epithelium, which plays a crucial role in maintaining their health. The cilia present in this epithelium aid in the removal of debris, mucus, and other particles from the sinuses. The normal course of this process is interrupted by the swelling of the mucous membranes, infiltration of lymphocytes and granulocytes, transformation of cells in the sinuses, and the excessive growth of fibroblasts after an episode of acute rhinosinusitis (Dinç et al., 2020; Qassim Mohammad et al., 2024).

The exact incidence of bacterial infection in patients diagnosed with acute rhinosinusitis (ARS) is uncertain because of the challenge of differentiating between viral and bacterial infections. Bacterial and viral acute respiratory syndromes (ARS) display similar clinical features. There are no clinical observations that may be utilized to forecast if acute respiratory syndrome (ARS) is caused by bacteria, such as alterations in the color or consistency of nasal discharge. Traditional imaging techniques lack the necessary precision and accuracy. Various imaging, clinical, and laboratory techniques have been used to improve the chances of accurately diagnosing bacterial acute rhinosinusitis (ARS) (Berger & Berger, 2011). The aim of the study is to identify the types of bacteria that cause sinusitis and find out the most effective types of antibiotics to optimise the success of treatment.

Materials amd methods

Standard microbiological procedures were used in the study to investigate 150 nasal swabs from patients presenting with sinusitis. The study involved individuals aged from 25 to 45 years. Sterile nasal swabs were collected from patients at Al-Habobbi Teaching Hospital, for the period between 10/2/2024 and 10/7/2024.

Before the samples were taken, all of the patients who were going to be part of this study were properly informed and gave their verbal permission. The Committee on Publication Ethics at the Thi-Qar Health Directorate, Al-Habbobi Teaching Hospital gave its approval to the study.

The patients were asked to assume a comfortable position with their heads slightly tilted back to facilitate access. A sterile swab was gently inserted into the nasal cavity and directed toward the sinus area. Care was taken to avoid causing any discomfort or injury. The swab was gently rolled to collect a sufficient sample from the mucosal surface. After collecting the sample, the swab was carefully withdrawn and placed in a sterile transport tube. The tube was closed and labeled with the relevant patient information. The collected samples were transported to the laboratory under appropriate conditions to prevent contamination or decomposition. Once the samples arrived at the laboratory, they were processed according to approved protocols for bacterial culture and susceptibility testing.

Using conventional microbiological techniques, we were able to identify the presence of the following bacteria ; *S. aureus*, *S. pneumonia*, *S. epidermidis*, *H. influenzae*, and *Moraxella catarrhalis*. Bacterial sinusitis was diagnosed using the Gram stained smear technique. Plates of Muller Hinton agar, eosin-methylene blue (EMB) agar, and blood agar were streaked to grow the samples. After that, the plates were heated to 37 °C and maintained in an oxygen-controlled chamber for at least two days. The features of the isolates' growth were written down. On many plates, there was no growth. The cultures were purified through subculturing and then stored in a refrigerator for further research. Gram staining and conventional biochemical tests including catalase, oxidase, mannitol salt agar (MSA), and hemolysis were used to identify the bacteria that were collected from the sinus after they were subjected to aerobic conditions. The hemolytic effects on human blood agar media were used to identify the *Streptococcus* and *Staphylococcus* types. There are many methods for detecting Gram-negative bacteria. They were identified using the gram stain, which appears red in color. They were identified using culture on media and also through biochemical tests such as oxidase, catalase, carbohydrate fermentation, and API (analytical profile index) test strips. Every single colony was cultivated overnight in nutritive broth to see how sensitive the isolates were to antibiotics. After dipping the sterile swab in the bacterial solution, it was rubbed across the platform to ensure that the bacteria were evenly disseminated across the Muller-Hinton agar medium. Antibiotic discs were used to carefully space the agar plates. This set of antibiotic discs had ampicillin, ceftriaxone, imipenem, cephazolin, gentamycin, nitrofurantoin, penicillin, streptomycin, vancomycin, clindamycin, erythromycin, and oxacillin on it. In our study, antibiotic discs produced by Liofilchem were used. We performed sensitivity analyses according to CLSI standards issued in 2023. We used standard control strains *Escherichia coli* and *S. aureus* to ensure the validity and accuracy of the test results.

Statistical analysis is often used to analyze quantitative data and provides methods for data description and simple inference for continuous and categorical data. The procedure involves the collection of data leading to a test of the relationship between two statistical data sets. All the information in this study is shown as the mean with a standard variation. The statistical studies were done with SPSS (version 26) and the dependent t-test (two-tailed) and the independent t-test (two-tailed) for variables with a normally distributed distribution. For variables with a non-normal distribution, the Mann-Whitney U test and the Wilcoxon test were used. $P < 0.05$ was seen as statistically significant.

Results

Bacterial species distribution in sinusitis cases. In the study, the distribution of positive and negative cases for different bacteria was analyzed. The results showed that the percentage of positive cases of *H. influenzae* bacteria was 36.7%, while the percentage of negative cases was 63.3%. For *Moraxella catarrhalis*, the percentage of positive cases was 24.7%, while the percentage of negative cases was 75.3%. As for *S. aureus* bacteria, the percentage of positive cases was 16.0%, while the percentage of negative cases was 84.0%. For *S. pneumoniae*, the percentage of positive cases was 15.3%, while the percentage of negative cases was 84.7%. Finally, for *S. epidermidis* bacteria, the percentage of positive cases was 8.0%, while the percentage of negative cases was 92.0%.

Table 1
Frequency and percentage of positive and negative cases for different bacterial species

Species		Number of cases	Frequency, %
Haemophilus influenzae	positive	55	36.7
	negative	95	63.3
Moraxella catarrhalis	positive	37	24.7
	negative	113	75.3
Staphylococcus aureus	positive	24	16.0
	negative	126	84.0
Streptococcus pneumoniae	positive	23	15.3
	negative	127	84.7
Staphylococcus epidermidis	positive	12	8.0
	negative	138	92.0
Total		150	100.0

Antibiotic susceptibility of Haemophilus influenzae in sinusitis cases. The sensitivity of *H. influenzae* to a group of antibiotics was evaluated, and the results shown in Table 2.

Table 2
Distribution of *Haemophilus influenzae* susceptibility, intermediate reaction and resistance to the various antibiotics

Antibiotics	Susceptibility		
	resistance	intermediate	sensitive
Ampicillin	1	54	0
Ceftriaxon	0	1	54
Imipenem	36	19	0
Cephazolin	55	0	0
Gentamycin	0	0	55
Nitrofurantoin	0	1	54
Vancomycin	0	0	55
Oxacillin	1	54	0
Penicillin	54	0	1
Erythromycin	0	1	54
Clindamycin	55	0	0

Antibiotic resistance profiles of Moraxella catarrhalis isolated from sinusitis patients. The sensitivity of *M. catarrhalis* to the various antibiotics was classified in Table 3.

Table 3
Classification of *Moraxella catarrhalis* resistance, intermediate susceptibility, and sensitivity to the various antibiotics

Antibiotics	Susceptibility		
	resistance	intermediate	sensitive
Ampicillin	37	0	0
Ceftriaxon	0	0	37
Imipenem	37	0	0
Cephazolin	0	37	0
Gentamycin	0	0	37
Nitrofurantoin	0	0	37
Vancomycin	37	0	0
Oxacillin	37	0	0
Penicillin	0	37	0
Erythromycin	4	0	33
Clindamycin	0	37	0

Antibiotic susceptibility patterns of Staphylococcus aureus isolated from sinusitis cases. The sensitivity of *S. aureus* to the various antibiotics is presented in Table 4.

Table 4
Analysis of *Staphylococcus aureus* resistance, intermediate susceptibility, and sensitivity to various antibiotics

Antibiotics	Susceptibility		
	resistance	intermediate	sensitive
Ampicillin	0	24	0
Ceftriaxon	0	0	24
Imipenem	0	24	0
Cephazolin	24	0	0
Gentamycin	0	0	24
Nitrofurantoin	0	24	0
Vancomycin	0	0	24
Oxacillin	0	24	0
Penicillin	11	13	0
Erythromycin	0	0	24
Clindamycin	0	24	0

Antibiotic susceptibility patterns of Streptococcus pneumoniae isolated from sinusitis cases. The sensitivity of *S. pneumoniae* to the various antibiotics is presented in Table 5.

Table 5
Analysis of *Streptococcus pneumoniae* resistance, intermediate susceptibility, and sensitivity to the various antibiotics

Antibiotics	Susceptibility		
	resistance	intermediate	sensitive
Ampicillin	22	0	0
Ceftriaxon	0	22	0
Imipenem	0	22	0
Cephazolin	22	0	0
Gentamycin	0	0	22
Nitrofurantoin	0	22	0
Vancomycin	0	0	22
Oxacillin	22	0	0
Penicillin	0	0	22
Erythromycin	0	22	0
Clindamycin	22	0	0

Antibiotic susceptibility profiles of Staphylococcus epidermidis isolated from sinusitis cases. The sensitivity of *S. epidermidis* to the various antibiotics is presented in Table 6.

Discussion

Acute rhinosinusitis (ARS) is a commonly observed condition in primary care settings, and it is a leading reason for prescribing antibiotics. Antibiotics are administered in 82–88% of patient visits for ARS (Dhar et al., 2024). Guidelines discourage the use of antibiotics in the majority of cases of acute respiratory syndrome (ARS), and a growing body of evidence suggests that antibiotics do not provide a significant advantage in most ARS cases. The main cause of acute bacterial rhinosinusitis is the small proportion of viral sinus infections that progress to this condition. However, the frequency of bacterial infection in acute rhinosinusitis (ARS) varies significantly in the scientific literature, ranging from 0.5% to 86%, depending on the population studied and the diagnostic method used to confirm bacterial sinusitis.

Table 6
Analysis of *Staphylococcus epidermidis* resistance, intermediate susceptibility, and sensitivity to various antibiotics

Antibiotics	Susceptibility		
	resistance	intermediate	sensitive
Ampicillin	12	0	0
Ceftriaxon	0	12	0
Imipenem	0	12	0
Cephazolin	12	0	0
Gentamycin	0	0	12
Nitrofurantoin	0	0	12
Vancomycin	0	12	0
Oxacillin	0	12	0
Penicillin	12	0	0
Erythromycin	0	0	12
Clindamycin	12	0	0

The proportion of positive incidents was as follows: *H. influenzae* accounts for 36.7% of the total; *M. catarrhalis* accounts for 24.7%; *S. aureus* accounts for 16.0%; *S. pneumoniae* accounts for 15.3%; and *S. epidermidis* accounts for 8.0%. *Moraxella catarrhalis* showed susceptibility to ceftriaxone, imipenem, vancomycin, and oxacillin. *H. influenzae* exhibited complete susceptibility to ceftriaxone, gentamycin, and vancomycin. The susceptibility of *S. aureus* to ceftriaxone, imipenem, gentamycin, vancomycin, and erythromycin has been proven. *S. pneumoniae* is more sensitive to penicillin, gentamycin, and vancomycin. *S. epidermidis*, on the other hand, is susceptible to gentamycin, nitrofurantoin, and erythromycin. This result corroborates (Leszczyńska et al., 2020; Alshehri et al., 2021; Jin et al., 2024). The precise etiology of the inflammation associated with ARS remains uncertain, however, there is substantial evidence indicating the presence of pathogens within the sinuses. Chronic sinusitis leads to a weakening of the individual's mucociliary clearance and host defences. This can reduce the sterility of the sinus cavity, allowing nasal flora to establish themselves. Chronic sinusitis may not truly be a "infectious process." Alternatively, it could be a deviation from the typical structure that leads to the rupture and leakage of the sinus cavity membrane. Doctors usually believe that bacteria play a significant role in the majority of instances of acute rhinosinusitis (ARS). Consequently, they recommend antimicrobial therapy. The causative bacteria of acute sinusitis are generally agreed upon by most individuals, while there is not a unanimous consensus regarding the specific microbes responsible for acute rhinosinusitis (ARS). Regrettably, numerous microbiological studies encounter issues that undermine their reliability, resulting in inconsistent findings (Wald, 1998). Concerns encompass the variation in methods of sampling the sinus cavity, failure to sterilise the path for the trocar or endoscope, sampling from different sinuses or areas such as the ethmoid bulla, maxillary antrum, or middle meatus, lack of measurement of the inflammatory response and bacterial count, selection of patients based on age, duration, and severity of the disease, inclusion of both surgical and non-surgical subjects, presence of nasal polyps, and alteration of the time and method of culture transport (Brown et al., 1998).

An ARS infection leads to the formation of a biofilm, which likely has a significant impact on the transmission and persistence of the disease in individuals (Dlugaszewska et al., 2016). The structure is tridimensional, with microorganisms adhering to it and an extracellular polymeric substance around it. The biofilm consists of a diverse array of microorganisms, which provide various benefits to the organisms. For instance, it provides protection to organisms that are susceptible to beta-lactam antibiotics by enveloping them with organisms that secrete beta-lactamases. Microorganisms possess several advantages over their competition, including quorum sensing systems, a larger gene pool with superior DNA, cooperative behaviour, and other processes that enhance their performance. When biofilms consist of a diverse range of microorganisms, they generally have a higher likelihood of survival (Wolcott et al., 2013).

One study found that the microorganisms most commonly associated with sinusitis were *S.aureus* (19%) and alpha-hemolytic streptococci (23%). Additionally, a separate study revealed that *S. epidermidis* and alpha-hemolytic streptococci were frequently identified. A study demonstrated that 25% of children with allergies exhibited polymicrobial flora. Nevertheless, *M. catarrhalis* was the most often encountered bacteria among them (Don et al., 2001). The presence of anaerobic bacteria in acute respiratory syndrome (ARS) in adults can be clinically significant. When analysing anaerobes at a concentration of more than 10^3 colony-forming units per millilitre, it was found that the recurrence of signs or symptoms of bacterial maxillary sinusitis connected with anaerobes happened twice as frequently as those associated with aerobes (Finegold et al., 2002).

Brook & Frazier (2001) conducted a study involving 108 patients diagnosed with chronic maxillary sinusitis. They examined the relationship between the microbiology of the sinuses and the patients' history of sinus surgery. The researchers found that individuals who had undergone previous sinus surgery had a higher likelihood of recovering *P. aeruginosa* and other Gram-negative bacilli. On the other hand, anaerobes were found more commonly among individuals who had not undergone previous surgery (Brook & Frazier, 2001).

Cleland et al. (2013) conducted a retrospective analysis of the aerobic bacteriology of chronic rhinosinusitis (CRS) in a cohort of 513 individuals who underwent sinus surgery. Organisms were rediscovered in 83% of instances, with an average of 0.95 isolates per patient. Approximately 35% of the patients were infected with *S. aureus*. Of the total, 19% were infected with *P. aeruginosa*, 7% with *Haemophilus spp.*, and 5% with *S. pneumoniae*. Patients who underwent a second surgical procedure had a significantly higher likelihood of acquiring *S. aureus* (P = 0.001), *P. aeruginosa* (P = 0.044), and a positive culture (P = 0.001). A significant correlation (P = 0.039) was seen between the quality of society and the prevalence of asthma.

There was no discernible disparity in the microbiological findings between patients with and without polyps (Cleland et al., 2013). Hamory et al. (1979) conducted a study at the University of Virginia in Charlottesville. The researchers examined 105 samples of aspirate obtained from 81 adult patients who had experienced illness for a duration exceeding seven days. The patients experienced unilateral facial pain and exhibited purulent nasal discharge. The maxillary sinuses were aspirated directly, and a substantial quantity of the aspirated material was cultured to detect the presence of viruses and bacteria. Among the 59 bacterial species detected at concentrations of 104 CFU/mL, *S. pneumoniae* (20 isolates, or 34%) and *H. influenzae* (18 isolates, or 30%) accounted for a combined total of 64%. Additionally, seven anaerobes, five species of *Neisseria*, and two variants of *Streptococcus pyogenes* were discovered: α-hemolytic streptococci and non-group A β-hemolytic streptococci.

Among the 70 samples that tested positive for culture, viruses were detected in 11, accounting for 16% of the samples. There were 6 instances of rhinovirus, 3 instances of influenza virus, and 2 instances of parainfluenza virus. There were a combination of several illnesses present in five of the sinuses (Hamory et al., 1979).

Following 15 years of extensive investigation Gwaltney et al. (1992) discovered the frequency of occurrence among 226 isolates derived from 383 aspirates collected from 339 individuals using identical methodology. The most prevalent causative agents were *S. pneumoniae*, accounting for 92 isolates (41% of cases), and *H. influenzae*, accounting for 79 isolates (35% of cases). Subsequently, a total of 16 anaerobic isolates (constituting 7% of the total) and 16 isolates of streptococcal species (also accounting for 7% of the total) were observed. Out of the total, 8 isolates were identified as *M. catarrhalis*, accounting for 4%. Out of the total isolates, seven were identified as *S. aureus*, accounting for 3% of the total.

Viruses such as rhinovirus, influenza virus, and parainfluenza virus are frequently detected in samples taken from the nose (Gwaltney et al., 1992). In 1996, collected data were published on the causes of community-acquired maxillary sinusitis from several studies. The findings revealed that unencapsulated *H. influenzae* and *S. pneumoniae* were the most often identified bacterial isolates in these cases. According to the three previously stated investigations, *S. pneumoniae* and *H. influenzae* were the most often identified microorganisms responsible for acute bacterial sinusitis. Over the past few years, the comparative significance of various bacterial strains responsible for bacterial sinusitis has remained mostly unchanged. However, there have been therapeutically significant alterations in their antibiotic responsiveness.

As stated in a different section of this article, there is growing concern among doctors and researchers regarding the increasing resistance of *S. pneumoniae* and other common respiratory pathogens. This includes their resistance to several medications (Karchmer, 2004). In addition, allergic illnesses contribute to the creation of a suitable environment for bacterial infection by causing inflammation of the mucosal lining, blockage of the ostial passages, and disruption of the mucociliary processes. Fortunately, some clinical indicators can assist in distinguishing between a rhinovirus-induced cold or bacterial sinusitis and a condition resembling allergy-induced sinusitis. Purulent nasal secretions are less likely to occur in individuals with an allergic diathesis, which is an important indicator. Furthermore, the primary clinical signs that are frequently observed in allergies are pruritus (itching) and sternutation (sneezing).

Ultimately, allergies frequently exhibit a persistent or recurring pattern and can render the patient susceptible to bacterial sinusitis. Recently, multiple organizations have released clinical practice guidelines aimed at assisting physicians in the diagnosis and treatment of sinusitis in both adults and children (Brooks et al., 2000). Although there are minor variations in these rules, the simplified algorithm presented is identical to the recommendations provided in each (Hickner et al., 2001). For instance, it is widely accepted that clinical manifestations are sufficient for diagnosing acute bacterial sinusitis, rendering imaging examinations typically unnecessary.

Antibiotics should only be prescribed to individuals who have exhibited signs and symptoms of bacterial sinusitis for a duration of 7 to 10 days, as the majority of sinusitis cases are caused by viruses and typically resolve without medical intervention. Patients who have definitive symptoms or those who are suspected of having significant issues should be excluded (Table 3) (Gonzales et al., 2001).

The objective of antimicrobial treatment is to achieve bacteriological and clinical resolution by eliminating the pathogens and any associated acute or chronic consequences. The consensus among the majority of individuals is that the antimicrobial medication should possess the ability to effectively eliminate both *S. pneumoniae* and *H. influenzae* (Leclercq, 2001). However, there is a lack of definitive guidelines about the optimal approach to treating acute bacterial sinusitis. Indeed, certain bacteria, particularly *S. pneumoniae*, are exhibiting an increasing level of resistance to routinely prescribed antibiotics such as amoxicillin, trimethoprim-sulfamethoxazole, as well as certain β-lactams and macrolides. Nevertheless, the impact of this on individuals with sinusitis has not been well investigated.

Ketolides, such as telithromycin and cethromycin, are highly effective in eliminating prevalent respiratory bacteria, including those responsible for acute sinusitis, without promoting resistance in these microorganisms. Research indicates that the treatment of acute maxillary sinusitis with a 5-day regimen of 800 mg once daily is highly effective, with a cure rate above 90%. Telithromycin is the initial ketolide compound that has undergone clinical studies. A reference agent (Luterman et al., 2003), was found to have identical findings, as reported in a recently published publication.

Brook et al. (2008) investigated the recovery rate of methicillin-resistant *S. aureus* (MRSA) in individuals suffering from chronic maxillary sinusitis during the time periods of 2001–2003 and 2004–2006. The study included a total of 214 patients who had chronic maxillary sinusitis. These individuals contributed to the cultivation of cultures that facilitated the recovery of 97 isolates between 2001 and 2003, and 117 isolates between 2004 and 2006. Twenty-three patients, accounting for 20% of those diagnosed with chronic sinusitis between 2004 and 2006, were impacted. Out of these, 14 (61%) were found to have MRSA. Similarly, a total of 15 individuals, accounting for 15% of the patients diagnosed with chronic sinusitis from 2001 to 2003, were affected. Out of these, four patients, which accounts for 27% of the total, were found to have MRSA.

Out of the patients with chronic sinusitis, antimicrobial treatment was administered to 122 individuals, which accounts for 57% of the total. Among the individuals in this group (28/122; 23%), MRSA was more frequently detected compared to those who had not received prior treatment (10/92 or 11%; P = 0.05). Kim et al. (2006) found that patients who had previously undergone sinus surgery or irrigation exhibited a higher prevalence of Gram-negative rods. In addition, *P. aeruginosa* was more frequently found in persons who were using systemic steroids. Additional research has also discovered that individuals who have undergone many treatments exhibit a shift towards Gram-negative microorganisms. Their bacterial isolates consist of MRSA, *H. influenzae*, *M. catarrhalis*, *Pseudomonas* spp., and *Enterobacter* spp (Liu et al., 2014).These authors investigated whether the diversity of bacteria residing in different subtypes of CRS might be used to predict clinical outcomes.

The effectiveness of antibiotic therapy is influenced by the dosage of the optimal agent, which should result in a medicine concentration above the minimum inhibitory concentration (MIC_{90}) for the specific pathogen. The pharmacokinetic and pharmacodynamic profile of an antimicrobial agent determines its ability to penetrate tissues at the site of infection, induce resistance, kill bacteria, prevent their growth, and determine the suitability of short-course treatment regimens based on its half-life. The importance of using the correct dosage in the treatment of community-acquired bacterial sinusitis is emphasised by a review of many antibiotic studies. These studies involved taking cultures of sinus aspirates before and after therapy to assess the effectiveness of the treatment on the microorganisms present. Two studies in this evaluation found that patients who had antibiotic concentrations above the minimum inhibitory concentration (MIC) for the pathogen throughout treatment had a bacteriologic cure rate of 90%.

However, according to Table 4, the percentage of patients who were successfully cured was only 45% when their antibiotic levels dropped below the minimum inhibitory concentration (MIC) for the specific organism. Additionally, it was discovered that in other comparable research, the rate of bacteriological cure was merely 71% for patients who were administered an insufficient quantity while it reached 93% for those who received an appropriate dosage of a potent medication. There has been no systematic investigation of the optimal duration of antibiotic treatment for sinusitis. A preliminary examination of the clinical and radiographic data comparing the treatment of sinusitis with trimethoprim-sulfamethoxazole for 3 days against 10 days indicated similar rates of clinical improvement (76% against 77%) (File, 2004). However, it is highly probable that the study included instances of viral sinusitis and did not depend on the results of sinus aspirate culture. In cases with uncomplicated sinusitis, a duration of 10 days is considered adequate. However, there are two significant therapeutic issues associated with long-term antibiotic treatment: patients are less inclined to adhere to their medication, and microorganisms develop resistance to antibiotics.

If the symptoms persist or fail to improve within three to five days of antibiotic treatment, it is highly likely that the sickness was caused by an antibiotic-resistant organism. This article explores the current developments in short-term antibiotic treatment, which could be intriguing for managing acute bacterial sinusitis (Liu et al., 2014).

Conclusion

The study concluded that the bacteria *H. influenzae* and *M. catarrhalis* were the most common in cases of sinusitis, accounting for 36.7% and 24.7%, respectively. These bacteria showed high sensitivity to antibiotics such as ceftriaxone, gentamycin, and vancomycin, which indicates the effectiveness of these antibiotics in treatment. This is due to the ability of these antibiotics to effectively inhibit the growth of bacteria and kill them. Other bacteria such as *S. aureus*, *S. pneumoniae*, and *S. epidermidis* showed varying susceptibility, reflecting the diversity in bacterial response to treatment. This research reinforces the importance of choosing the appropriate antibiotic based on the sensitivity of bacteria to ensure the effectiveness of treatment and limit the development of bacterial resistance to antibiotics.

References

Abbas, Z. K., Hilo, Z. Q. M., Hussein, W. S. A., & Mohsein, O. A. (2025). Immunological biomarkers and their role in the diagnosis and prognosis of leishmaniasis: A case-control study. Tropical Parasitology, 15(1), 33–41.

Alshehri, A. M. S., Assiri, O. A., Alqarni, A. M. S., Alkhairi, M. A. Y., Alzahrani, M. A. A., Alshehri, S. H. A., Alshehri, N. A. A., & Abouelyazid, A. Y. (2021). Prevalence and clinical presentation of sinusitis in pediatric age group in Aseer, Saudi Arabia. Journal of Family Medicine and Primary Care, 10(6), 2358–2362.

Bahethi, R., Talmor, G., Choudhry, H., Lemdani, M., Singh, P., Patel, R., & Hsueh, W. (2024). Chronic invasive fungal rhinosinusitis and granulomatous invasive fungal sinusitis: A systematic review of symptomatology and outcomes. American Journal of Otolaryngology, 45(1), 104064.

Berger, G., & Berger, R. L. (2011). The contribution of flexible endoscopy for diagnosis of acute bacterial rhinosinusitis. European Archives of Oto-Rhino-Laryngology – Head and Neck Surgery, 268(2), 235–240.

Biel, M. A., Brown, C. A., Levinson, R. M., Garvis, G. E., Paisner, H. M., Sigel, M. E., & Tedford, T. M. (1998). Evaluation of the microbiology of chronic maxillary sinusitis. Annals of Otology, Rhinology, and Laryngology, 107(11), 942–945.

Brook, I., & Frazier, E. H. (2001). Correlation between microbiology and previous sinus surgery in patients with chronic maxillary sinusitis. Annals of Otology, Rhinology, and Laryngology, 110(2), 148–151.

Brook, I., Foote, P. A., & Hausfeld, J. N. (2008). Increase in the frequency of recovery of meticillin-resistant *Staphylococcus aureus* in acute and chronic maxillary sinusitis. Journal of Medical Microbiology, 57(8), 1015–1017.

Brooks, I., Gooch 3rd, W. M., Jenkins, S. G., Pichichero, M. E., Reiner, S. A., Sher, L., & Yamauchi, T. (2000). Medical management of acute bacterial sinusitis. Recommendations of a clinical advisory committee on pediatric and adult sinusitis. Annals of Otology, Rhinology and Laryngology, 182S, 2–20.

Chow, A. W., Benninger, M. S., Brook, I., Brozek, J. L., Goldstein, E. J., Hicks, L. A., Pankey, G. A., Seleznick, M., Volturo, G., Wald, E. R., File Jr., T. M., & Infectious Diseases Society of America (2012). IDSA clinical practice guideline for acute bacterial rhinosinusitis in children and adults. Clinical Infectious Diseases, 54(8), e72–e112.

Cleland, E. J., Bassiouni, A., & Wormald, P. J. (2013). The bacteriology of chronic rhinosinusitis and the pre-eminence of *Staphylococcus aureus* in revision patients. International Forum of Allergy and Rhinology, 3(8), 642–646.

Dhar, S., Kothari, D. S., Tomescu, A. L., D'Anza, B., Rodriguez, K., Sheyn, A., & Rangarajan, S. V. (2024). Antimicrobial prescription patterns for acute sinusitis 2015–2022: A comparison to published guidelines. American Journal of Rhinology and Allergy, 38(6), 421–427.

Dinç, M. E., Bayar Muluk, N., & Vonakis, B. M. (2019). Physiology of the nose and paranasal sinuses. In: Cingi, C., & Muluk, N. B. (Eds.). All around the nose. Springer, Cham. Pp. 57–63.

Dlugaszewska, J., Leszczynska, M., Lenkowski, M., Tatarska, A., Pastusiak, T., & Szyfter, W. (2016). The pathophysiological role of bacterial biofilms in chronic sinusitis. European Archives of Oto-Rhino-Laryngology – Head and Neck Surgery, 273(8), 1989–1994.

Don, D. M., Yellon, R. F., Casselbrant, M. L., & Bluestone, C. D. (2001). Efficacy of a stepwise protocol that includes intravenous antibiotic therapy for the management of chronic sinusitis in children and adolescents. Archives of Otolaryngology – Head and Neck Surgery, 127(9), 1093–1098.

Essa, S. H., Mohammad, S. Q., Kadhum, D. A., & Jalil, I. S. (2024). Effectiveness of silver nanoparticles as antibacterial agents with natural wound healing cream with extracted *Aloe vera* gel. Regulatory Mechanisms in Biosystems, 15(4), 821–825.

File, T. M. (2004). Clinical efficacy of newer agents in short-duration therapy for community-acquired pneumonia. Clinical Infectious Diseases, 39(S3), S159–S164.

Finegold, S. M., Flynn, M. J., Rose, F. V., Jousimies-Somer, H., Jakielaszek, C., McTeague, M., Wexler, H. M., Berkowitz, E., & Wynne, B. (2002). Bacteriologic findings associated with chronic bacterial maxillary sinusitis in adults. Clinical Infectious Diseases, 35(4), 428–433.

Furkatov, S. F., Khazratov, A. I., Alikulov, O. A., & Sheraliev, M. S. (2025). Maxillary sinusitis: Causes, symptoms, diagnosis, therapy. Multidisciplinary Journal of Science and Technology, 5(2), 107–110.

Gonzales, R., Bartlett, J. G., Besser, R. E., Cooper, R. J., Hickner, J. M., Hoffman, J. R., & Sande, M. A. (2001). Principles of appropriate antibiotic use

for treatment of acute respiratory tract infections in adults: Background, specific aims, and methods. Annals of Internal Medicine, 134(6), 479–486.
Gwaltney Jr., J. M., Scheld, W. M., Sande, M. A., & Sydnor, A. (1992). The microbial etiology and antimicrobial therapy of adults with acute community-acquired sinusitis: A fifteen-year experience at the University of Virginia and review of other selected studies. The Journal of Allergy and Clinical Immunology, 90(3), 457–462.
Hamory, B. H., Sande, M. A., Sydnor Jr., A., Seale, D. L., & Gwaltney Jr., J. M. (1979). Etiology and antimicrobial therapy of acute maxillary sinusitis. The Journal of Infectious Diseases, 139(2), 197–202.
Hemmati, Z., Borchaloee, A. S., Bazrafshan, F., Latibari, B. J., Ghaziani, P. M., & Khou, M. H. (2023). Study on the prevalence of methicillin-resistant *Staphylococcus aureus* infection, antibiotic resistance pattern, biofilms genes, and antibiotic resistance genes from clinical samples. Archives of Razi Institute, 79(5), 923–928.
Hickner, J. M., Bartlett, J. G., Besser, R. E., Gonzales, R., Hoffman, J. R., Sande, M. A., American Academy of Family Physicians, American College of Physicians-American Society of Internal Mediciine, Centers for Disease Control, & Infectious Diseases Society of America (2001). Principles of appropriate antibiotic use for acute rhinosinusitis in adults: Background. Annals of Internal Medicine, 134(6), 498–505.
Jin, V., Chiu, R., Patel, M., Zhu, A., Perez, B., & Lee, V. (2024). Trends and frequencies of antibiotic prescriptions for acute sinusitis outpatient visits in adults. The Laryngoscope, 134(6), 2622–2625.
Karchmer, A. W. (2004). Increased antibiotic resistance in respiratory tract pathogens: Protekt us – an update. Clinical Infectious Diseases, 39(S3), S142–S150.
Kim, H. J., Lee, K., Yoo, J. B., Song, J. W., & Yoon, J. H. (2006). Bacteriological findings and antimicrobial susceptibility in chronic sinusitis with nasal polyp. Acta Oto-Laryngologica, 126(5), 489–497.
Leclercq, R. (2001). Overcoming antimicrobial resistance: Profile of a new ketolide antibacterial, telithromycin. Journal of Antimicrobial Chemotherapy, 48(S1), 9–23.
Leszczyńska, J., Stryjewska-Makuch, G., Ścierski, W., & Lisowska, G. (2020). Bacterial flora of the nose and paranasal sinuses among patients over 65 years old with chronic rhinosinusitis who underwent endoscopic sinus surgery. Clinical Interventions in Aging, 15, 207–215.
Liu, Q., Lu, X., Bo, M., Qing, H., Wang, X., & Zhang, L. (2014). The microbiology of chronic rhinosinusitis with and without nasal polyps. Acta Oto-Laryngologica, 134(12), 1251–1258.
Min, H. K., Lee, S., Kim, S., Son, Y., Park, J., Kim, H. J., Lee, J., Lee, H., Smith, L., Rahmati, M., Kang, J., Papadopoulos, N. G., Cho, S. H., Hahn, J. W., & Yon, D. K. (2025). Global incidence and prevalence of chronic rhinosinusitis: A systematic review. Clinical and Experimental Allergy, 55(1), 52–66.
Mohammad, S. Q., Awayid, H. S., & Zarrouk-Mahjoub, S. (2025). Identification of virulence genes from clinical isolates of methicillin-resistant *Staphylococcus aureus* (MRSA). Biodiversitas, 25(12), 5083–5093.
Mohammad, S., Mohsen, A., & Jalil, I. (2024). Assessing the prevalence of bacterial vaginosis among infertile women in Thi-Qar Province, Iraq. Infection Epidemiology and Microbiology, 10(4), 287–296.
Qassim Mohammad, S., Khazal Mohsen, A., Saleh Jalil, I., & Akram Mohsein, O. (2024). Assessing the prevalence of bacterial vaginosis among infertile women in Thi-Qar Province, Iraq. Infection Epidemiology and Microbiology, 10(4), 287–296.
Rosenfeld, R. M. (2016). Acute sinusitis in adults. New England Journal of Medicine, 375(10), 962–970.
Wald, E. R. (1998). Microbiology of acute and chronic sinusitis in children and adults. The American Journal of the Medical Sciences, 316(1), 13–20.
Wolcott, R., Costerton, J. W., Raoult, D., & Cutler, S. J. (2013). The polymicrobial nature of biofilm infection. Clinical Microbiology and Infection, 19(2), 107–112.