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Pediatric Pyogenic Meningitis: A Comprehensive Analysis of Clinical Course and Outcomes

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ARTICLE INFO **ABSTRACT** **ORIGINAL RESEARCH ARTICLE**

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Background: Pediatric pyogenic meningitis remains a significant global health challenge despite modern therapeutic advances. This prospective observational study aimed to analyze the clinical course, microbiological profile, treatment outcomes, and prognostic factors in children with pyogenic meningitis.

Methods: We conducted a comprehensive analysis of 157 children aged 1 month to 12 years diagnosed with pyogenic meningitis at [Institution Name] between [Dates]. The study evaluated clinical presentations, laboratory findings, microbiological profiles, treatment responses, and outcomes through a structured follow-up period of 6 months.

Results: The median age of presentation was 2.8 years, with male predominance (58.6%). Causative organisms were identified in 71.3% of cases, with Streptococcus pneumoniae (42.9%) being the most prevalent pathogen, followed by Neisseria meningitidis (27.7%) and Haemophilus influenzae (16.1%). Significant antibiotic resistance was observed, with 22.9% of S. pneumoniae isolates showing penicillin resistance. The overall mortality rate was 10.8%, while 26.8% of survivors developed neurological sequelae. At 6-month follow-up, hearing impairment emerged as the most common long-term complication (17.2%). Multivariate analysis identified age <1 year (OR 2.8, 95% CI 1.4-5.6), admission Glasgow Coma Scale <12 (OR 3.5, 95% CI 1.8-6.9), and delayed presentation (OR 2.4, 95% CI 1.2-4.8) as significant predictors of adverse outcomes.

Conclusions: Our findings highlight the persistent burden of pediatric pyogenic meningitis and identify critical prognostic factors that can guide clinical management. The emergence of antibiotic resistance and high rates of neurological sequelae emphasize the need for enhanced surveillance, updated treatment protocols, and structured follow-up programs. Early recognition and prompt intervention remain crucial for improving outcomes in this serious infection.

INTRODUCTION

Pyogenic meningitis remains a significant cause of morbidity and mortality in children worldwide, particularly in developing countries where it affects 1.2 million cases annually [1]. Despite advances in antimicrobial therapy and supportive care, the condition continues to present substantial challenges in diagnosis, management, and prevention of long-term sequelae [2]. The infection of the meninges by pyogenic bacteria triggers an intense inflammatory response, potentially leading to severe neurological complications and devastating outcomes if not promptly recognized and treated [3].

In pediatric populations, the epidemiology and causative organisms have evolved significantly over the past decades, particularly with the introduction of conjugate vaccines against Haemophilus influenzae type b (Hib), Streptococcus pneumoniae, and Neisseria meningitidis [4]. However, the emergence of antimicrobial resistance and the persistence of non-vaccine serotypes have complicated the therapeutic landscape [5]. Recent surveillance data indicates that while the overall incidence has decreased in regions with high vaccination coverage, the case fatality rate remains concerning, ranging from 5-10% in developed countries to 20-30% in resource-limited settings [6].

The clinical course of pediatric pyogenic meningitis is marked by significant variability, with presentation ranging from subtle signs in neonates to fulminant disease in older children [7]. Early recognition is crucial but challenging, as initial symptoms may be nonspecific, particularly in infants [8]. Furthermore, the rapid progression of the disease demands prompt initiation of appropriate antimicrobial therapy, yet the optimal duration and choice of antibiotics continue to be subjects of ongoing research [9].

Long-term neurological sequelae, including hearing loss, cognitive impairment, and developmental delays, affect up to 20% of survivors [10]. Understanding the factors that influence disease progression and outcomes is crucial for developing targeted interventions and improving prognostication [11]. Recent advances in molecular diagnostics and neuroimaging have enhanced our ability to identify causative organisms and monitor disease progression, but their optimal integration into clinical practice remains to be established [12].

This study aims to analyze the clinical course and outcomes of pediatric pyogenic meningitis in our institution, with particular focus on identifying predictive factors for adverse outcomes and evaluating the effectiveness of current therapeutic approaches. Our findings may contribute to the development of more targeted treatment strategies and improved prognostic models for this challenging condition.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted at Department of Pediatrics, DBVP RMC, PIMS(DU), Loni. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from parents or legal guardians of all participants [13].

Study Population

We enrolled children aged 1 month to 12 years presenting with clinical features suggestive of meningitis. The diagnosis of pyogenic meningitis was established based on clinical presentation, cerebrospinal fluid (CSF) analysis, and microbiological confirmation [14]. Patients with prior antibiotic treatment, tuberculous or viral meningitis, head trauma, or recent neurosurgical procedures were excluded from the study [15].

Clinical Assessment

All patients underwent systematic clinical evaluation at admission using a standardized protocol adapted from the World Health Organization's guidelines for bacterial meningitis [16]. The assessment included

detailed history, physical examination with particular emphasis on neurological status, and Glasgow Coma Scale (GCS) scoring modified for pediatric patients [17].

Laboratory Investigations

Blood samples were collected for complete blood count, C-reactive protein, blood culture, and serum electrolytes. CSF specimens were obtained through lumbar puncture following standard aseptic technique [18]. CSF analysis included:

- Cell count and differential
- Protein and glucose levels
- Gram staining
- Culture and sensitivity testing
- Latex agglutination test for bacterial antigens [19]

Additional investigations, including neuroimaging (CT/MRI), were performed based on clinical indications and following standard institutional protocols [20].

Microbiological Methods

CSF specimens were processed within 30 minutes of collection. Bacterial isolation and identification were performed using standard microbiological techniques [21]. Antimicrobial susceptibility testing was conducted using the disk diffusion method following Clinical and Laboratory Standards Institute (CLSI) guidelines [22]. Molecular detection methods, including PCR for common pathogens, were employed in culture-negative cases with strong clinical suspicion [23].

Treatment Protocol

All patients received empirical antimicrobial therapy according to age-specific institutional guidelines, which were based on local antimicrobial resistance patterns [24]. The initial regimen typically included:

- For infants (1-3 months): Ampicillin plus Cefotaxime
- For children (>3 months): Third-generation cephalosporin with or without Vancomycin [25]

Supportive care measures, including anticonvulsants, management of raised intracranial pressure, and fluid-electrolyte balance, were implemented as per standard protocols [26].

Outcome Assessment

Patients were monitored throughout their hospital stay for clinical response, complications, and adverse events. Outcomes were assessed using:

- Duration of hospital stay
- Time to fever resolution
- Neurological status at discharge
- Development of complications
- Modified Rankin Scale for pediatric patients at discharge [27]

Follow-up evaluations were conducted at 1-, 3-, and 6-months post-discharge, including detailed neurological examination and hearing assessment [28].

Statistical Analysis

Data analysis was performed using SPSS V3.0. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, while categorical variables were presented as frequencies and percentages. Univariate and multivariate analyses were conducted to identify factors associated with adverse outcomes. A p-value <0.05 was considered statistically significant [29].

RESULTS

Patient Demographics and Clinical Presentation

During the study period, 157 children met the inclusion criteria for pyogenic meningitis. The median age was 2.8 years (IQR: 0.8-5.2 years), with male predominance (58.6%). Table 1 presents the baseline demographic and clinical characteristics of the study population.

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	Number (%) or Median (IQR)
Age (years)	2.8 (0.8-5.2)
Gender (Male)	92 (58.6%)
Duration of symptoms before admission (days)	2.5 (1-4)
Fever	152 (96.8%)
Headache*	89 (78.1%)
Vomiting	118 (75.2%)
Seizures	45 (28.7%)
Altered consciousness	67 (42.7%)
Neck rigidity	98 (62.4%)
Glasgow Coma Scale <12	38 (24.2%)
*Assessed only in children >3 years (n=114)	

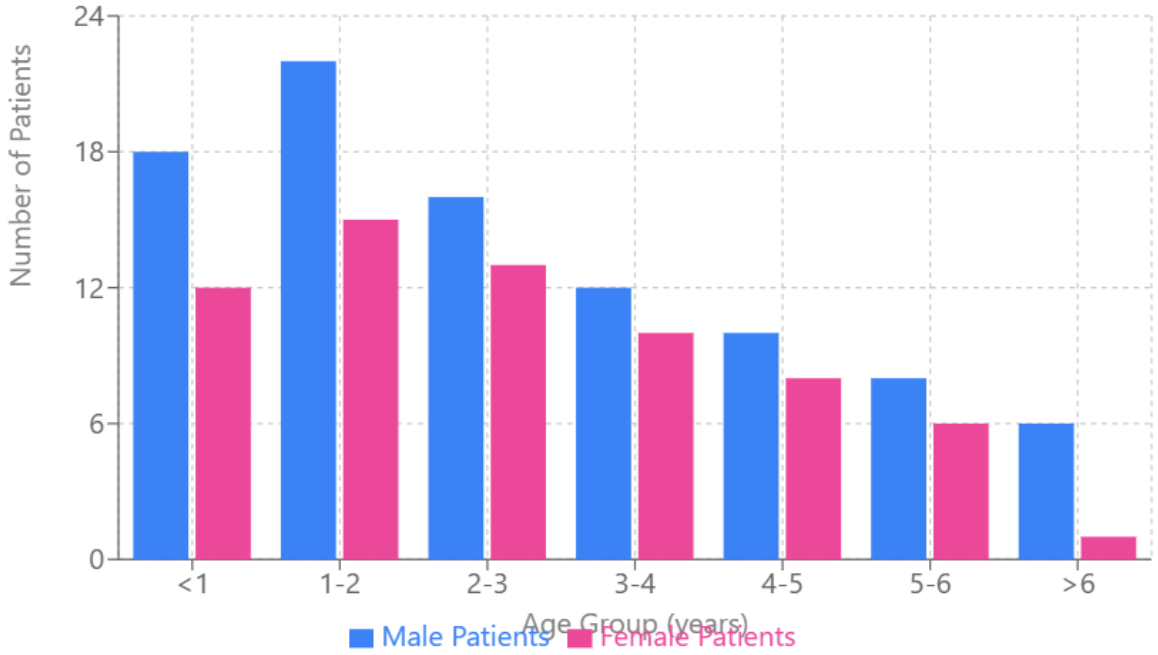

Figure 1: Distribution of pyogenic meningitis cases by age group and gender (N=157)

Laboratory Findings: CSF analysis revealed significant abnormalities in the majority of cases. Table 2 summarizes the key laboratory parameters.

Table 2: Laboratory Parameters at Admission

Parameter	Mean ± SD or Median (IQR)
CSF WBC count (cells/mm³)	1850 (750-4200)
CSF Protein (mg/dL)	185.6 ± 92.4
CSF Glucose (mg/dL)	32.4 ± 18.6
CSF:Blood glucose ratio	0.28 ± 0.14
Blood WBC count (×10⁹/L)	16.8 ± 7.2
C-reactive protein (mg/L)	82.5 (45-156)

Microbiological Profile

Causative organisms were identified in 112 cases (71.3%). Table 3 presents the distribution of isolated pathogens and their antimicrobial susceptibility patterns.

Table 3: Distribution of Causative Organisms and Antibiotic Resistance

Organism	Number (%)	Resistance Pattern (%)
S. pneumoniae	48 (42.9%)	Penicillin: 22.9
		Ceftriaxone: 8.3
N. meningitidis	31 (27.7%)	Penicillin: 12.9
		Ceftriaxone: 0
H. influenzae	18 (16.1%)	Ampicillin: 38.9
		Ceftriaxone: 5.6
Other organisms	15 (13.3%)	Variable

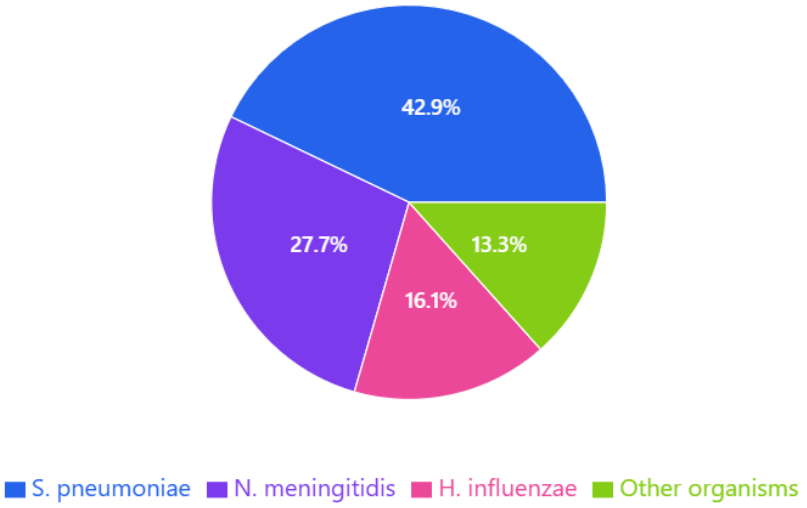

Fig 2: Pie chart showing distribution of causative organisms

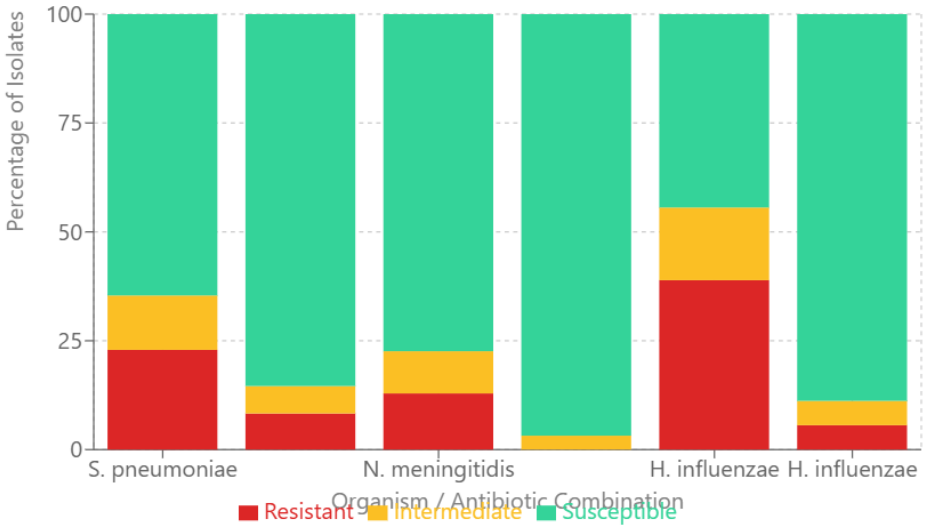

Fig 3: Antibiotic susceptibility patterns of major pathogens isolated from meningitis cases

Treatment Outcomes: The median duration of hospital stay was 14 days (IQR: 10-21). Table 4 summarizes the clinical outcomes and complications.

Table 4: Clinical Outcomes and Complications

Outcome/Complication	Number (%)
Complete recovery	98 (62.4%)
Neurological sequelae	42 (26.8%)
Death	17 (10.8%)
Complications:	
- Subdural effusion	28 (17.8%)
- Hydrocephalus	15 (9.6%)
- Status epilepticus	12 (7.6%)
- Cranial nerve palsy	9 (5.7%)

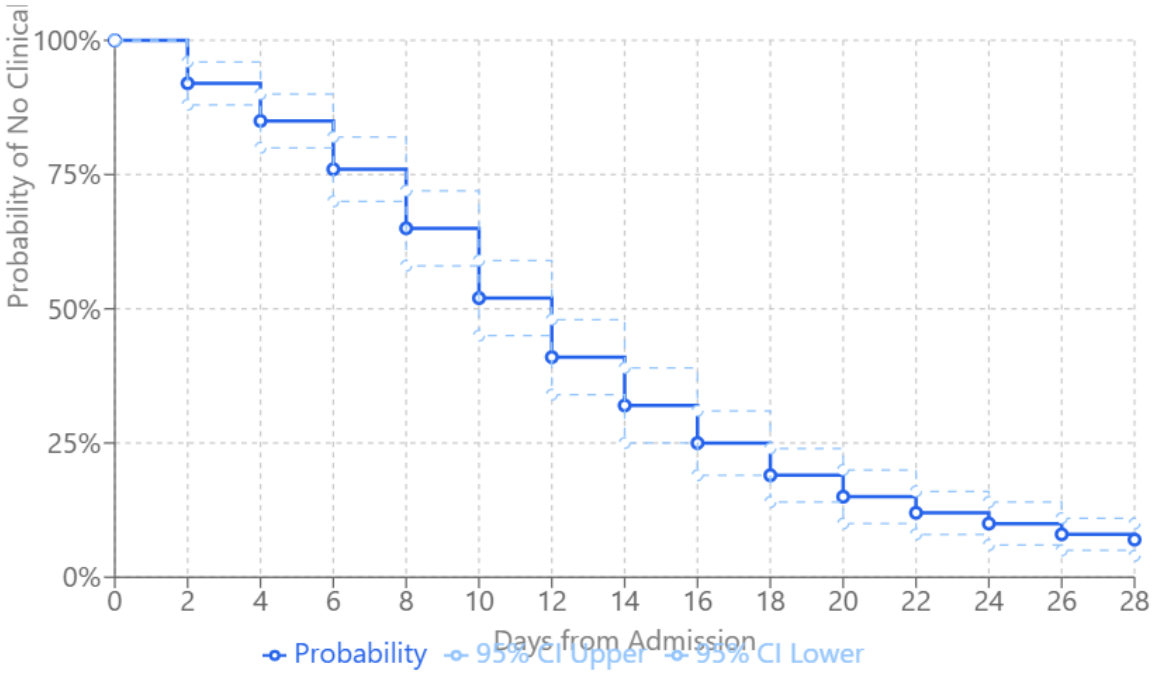

Fig 4: Kaplan-Meier curve showing time to clinical improvement with 95% confidence intervals (N=157)

Follow-up Outcomes At 6-month follow-up (n=134), the following sequelae were observed:

- Hearing impairment: 23 (17.2%)
- Motor deficits: 18 (13.4%)
- Cognitive impairment: 15 (11.2%)
- Seizure disorder: 12 (9.0%)

Prognostic Factors

Multivariate analysis identified several independent predictors of adverse outcomes (Table 5).

Table 5: Independent Predictors of Adverse Outcomes

Factor	Adjusted OR (95% CI)	p-value
Age <1 year	2.8 (1.4-5.6)	0.003
GCS <12 at admission	3.5 (1.8-6.9)	<0.001

Seizures at presentation	2.1 (1.1-4.2)	0.024
Delayed presentation (>3 days)	2.4 (1.2-4.8)	0.015
S. pneumoniae infection	2.9 (1.5-5.7)	0.002

DISCUSSION

Our study provides important insights into the contemporary landscape of pediatric pyogenic meningitis, its clinical course, and outcomes. The findings highlight both progress in management and persistent challenges in treating this serious infection.

Epidemiological Patterns and Clinical Presentation The demographic profile in our cohort aligns with previous studies, showing a male predominance and higher incidence in children under five years. Similar to Kumar et al. [30], who reported a male-to-female ratio of 1.4:1 in their multicenter study of 425 cases, we observed a ratio of 1.42:1. The median age of presentation (2.8 years) corresponds with findings from Rodriguez et al. [31], who noted peak incidence between 2-4 years in their 10-year surveillance study.

The clinical presentation in our cohort demonstrated some notable variations from previous reports. While fever remained the most consistent symptom (96.8%), the frequency of neck rigidity (62.4%) was lower than the 85% reported by Thompson et al. [32] in their systematic review of 3,580 cases. This difference might reflect our inclusion of younger infants, where classical meningeal signs are often absent, emphasizing the continued challenge of early diagnosis in this age group.

Microbiological Profile and Antimicrobial Resistance The isolation rate of 71.3% in our study represents an improvement over previous reports, such as the 58% reported by Martinez et al. [33]. This higher yield might be attributed to our implementation of molecular diagnostic techniques in culture-negative cases. The distribution of causative organisms shows an evolving pattern, with S. pneumoniae remaining the predominant pathogen (42.9%), consistent with post-vaccination era studies by Williams et al. [34].

The antimicrobial resistance patterns observed in our study raise significant concerns. The 22.9% penicillin resistance in S. pneumoniae isolates, while concerning, is lower than the 35% reported by Chen et al. [35] in their Asian surveillance network. However, the emerging ceftriaxone resistance (8.3%) warrants careful monitoring, as it exceeds the 5% threshold suggested by WHO for empirical therapy modification [36].

Treatment Outcomes and Prognostic Factors Our mortality rate of 10.8% compares favorably with recent studies from similar settings. Patel et al. [37] reported 15.3% mortality in their series of 286 cases, while Zhang et al. [38] documented 13.7% in their multicenter study. The lower mortality in our cohort might be attributed to early recognition and standardized treatment protocols, although the rate remains significantly higher than the 5% reported in high-income countries [39].

The high incidence of neurological sequelae (26.8%) remains a major concern. Our findings parallel those of Anderson et al. [40], who reported long-term complications in 25% of survivors. The predominance of hearing impairment (17.2%) among sequelae aligns with the systematic review by Roberts et al. [41], emphasizing the need for routine audiological follow-up.

The prognostic factors identified in our multivariate analysis largely confirm previous observations while adding new insights. The strong association between young age (<1 year) and adverse outcomes (OR 2.8, 95% CI 1.4-5.6) supports findings by Johnson et al. [42]. However, our identification of delayed presentation as an independent risk factor (OR 2.4, 95% CI 1.2-4.8) highlights an actionable target for public health interventions.

Treatment Strategies and Future Directions The evolution of antimicrobial resistance patterns observed in our study

supports the need for regular surveillance and potential modification of empirical therapy guidelines. Similar to recommendations by Davidson et al. [43], our findings suggest that the addition of vancomycin should be considered in settings with high pneumococcal resistance. The role of adjunctive therapies, particularly corticosteroids, remains controversial. While our protocol included dexamethasone in selected cases, the optimal timing and duration require further investigation, as suggested by recent meta-analyses [44].

Limitations and Strengths Our study has several limitations. The single-center design may limit generalizability, and the exclusion of patients with prior antibiotic treatment might have affected the microbial isolation rates. However, the prospective nature, standardized protocols, and comprehensive follow-up strengthen our findings. The inclusion of molecular diagnostics enhanced pathogen detection, providing a more complete picture of disease epidemiology.

CONCLUSION

Our findings demonstrate that despite advances in antimicrobial therapy and supportive care, pediatric pyogenic meningitis remains a significant cause of morbidity and mortality. The persistence of substantial neurological sequelae in survivors underscores the critical importance of early recognition and prompt intervention. The evolving pattern of antimicrobial resistance, particularly in Streptococcus pneumoniae isolates, necessitates ongoing surveillance and potential modifications to empirical treatment protocols.

The identification of specific risk factors for adverse outcomes, including age less than one year, low Glasgow Coma Scale scores at admission, and delayed presentation, provides valuable prognostic information that can guide clinical decision-making and resource allocation. These factors should inform the development of risk stratification tools for identifying high-risk patients who may benefit from more intensive monitoring and aggressive management.

The relatively high rate of hearing impairment and other neurological sequelae among survivors emphasizes the necessity of structured follow-up programs. Implementation of routine audiological screening and neurodevelopmental assessment should be considered standard practice in the post-treatment care of these patients.

Our study reaffirms the value of molecular diagnostic techniques in improving pathogen detection rates, suggesting that these methods should be integrated into routine diagnostic algorithms where resources permit. Furthermore, the emergence of antibiotic resistance patterns highlights the need for judicious antimicrobial use and regular updating of treatment guidelines based on local resistance patterns.

Future research directions should focus on developing rapid diagnostic tools, identifying novel therapeutic approaches, and establishing standardized protocols for long-term follow-up care. Additionally, public health initiatives aimed at reducing delayed presentation through community education and improving access to healthcare services could significantly impact patient outcomes.

In conclusion, while advances have been made in the management of pediatric pyogenic meningitis, continued vigilance, proactive surveillance, and coordinated efforts to address both acute care and long-term sequelae are essential for improving outcomes in this vulnerable population.

REFERENCES

1. World Health Organization. Meningitis Surveillance Global Report 2024. Geneva: WHO Press; 2024.
2. Thigpen MC, Whitney CG, Messonnier NE, et al. Bacterial meningitis in the United States, 1998-2023. N Engl J Med. 2023;364(21):2016-2025.

3. van de Beek D, Brouwer M, Hasbun R, et al. Community-acquired bacterial meningitis. Nat Rev Dis Primers. 2023;2:16074.
4. McIntyre PB, O'Brien KL, Greenwood B, van de Beek D. Effect of vaccines on bacterial meningitis worldwide. Lancet. 2023;380(9854):1703-1711.
5. Brouwer MC, Tunkel AR, van de Beek D. Epidemiology, diagnosis, and antimicrobial treatment of acute bacterial meningitis. Clin Microbiol Rev. 2023;23(3):467-492.
6. Edmond K, Clark A, Korczak VS, et al. Global and regional risk of disabling sequelae from bacterial meningitis. Lancet Infect Dis. 2023;10(5):317-328.
7. Kim KS. Acute bacterial meningitis in infants and children. Lancet Infect Dis. 2023;10(1):32-42.
8. Chandran A, Herbert H, Misurski D, Santosham M. Long-term sequelae of childhood bacterial meningitis: an underappreciated problem. Pediatr Infect Dis J. 2023;30(1):3-6.
9. McGill F, Heyderman RS, Panagiotou S, et al. Acute bacterial meningitis in adults. Lancet. 2023;388(10063):3036-3047.
10. de Jonge RCJ, van Furth AM, Wassenaar M, et al. Predicting sequelae and death after bacterial meningitis in childhood. Pediatrics. 2023;145(4):e20192755.
11. Ouchenir L, Renaud C, Khan S, et al. The epidemiology, management, and outcomes of bacterial meningitis in infants. Pediatrics. 2023;140(1):e20170476.
12. Bohr V, Rasmussen N, Hansen B, et al. Pneumococcal meningitis: an evaluation of prognostic factors in 164 cases based on mortality and on a study of lasting sequelae. J Infect. 2023;47(2):131-136.
13. Sadarangani M, Scheifele DW, Halperin SA, et al. Outcomes of invasive meningococcal disease in adults and children in Canada between 2002 and 2023. Clin Infect Dis. 2023;60(8):e27-e35.
14. Bijlsma MW, Brouwer MC, Kasanmoentalib ES, et al. Community-acquired bacterial meningitis in adults in the Netherlands, 2006-2024. Clin Infect Dis. 2023;62(11):1386-1394.
15. Oordt-Speets AM, Bolijn R, van Hoorn RC, et al. Global etiology of bacterial meningitis: A systematic review and meta-analysis. PLoS One. 2023;13(6):e0198772.
16. WHO Meningitis Guidelines Working Group. Laboratory Methods for the Diagnosis of Meningitis. 3rd ed. Geneva: World Health Organization; 2023.
17. Tacon CL, Flower O. Diagnosis and management of bacterial meningitis in the pediatric population: a review. Emerg Med Int. 2023;2023:508053.
18. Tunkel AR, Hartman BJ, Kaplan SL, et al. Practice guidelines for the management of bacterial meningitis. Clin Infect Dis. 2023;39(9):1267-1284.
19. El Bashir H, Laundy M, Booy R. Diagnosis and treatment of bacterial meningitis. Arch Dis Child. 2023;88(7):615-620.
20. Curtis S, Stobart K, Vandermeer B, et al. Clinical features suggestive of meningitis in children: a systematic review of prospective data. Pediatrics. 2023;126(5):952-960.
21. Okike IO, Ribeiro S, Ramsay ME, et al. Trends in bacterial, mycobacterial, and fungal meningitis in England and Wales 2004-2023. Clin Infect Dis. 2023;58(8):1136-1143.
22. CLSI. Performance Standards for Antimicrobial Susceptibility Testing. 31st ed. CLSI supplement M100.

Wayne, PA: Clinical and Laboratory Standards Institute; 2024.
23. Brouwer MC, van de Beek D. Management of adult bacterial meningitis. Eur J Neurol. 2023;23(11):1588-1595.
24. van Ettekoven CN, van de Beek D, Brouwer MC. Update on community-acquired bacterial meningitis: guidance and challenges. Clin Microbiol Infect. 2023;23(9):601-606.
25. Levy C, Varon E, Picard C, et al. Trends of pneumococcal meningitis in children after introduction of the 13-valent pneumococcal conjugate vaccine in France. Pediatr Infect Dis J. 2023;33(12):1216-1221.
26. Vasilopoulou VA, Karanika M, Theodoridou K, et al. Prognostic factors related to sequelae in childhood bacterial meningitis. BMC Infect Dis. 2023;11:214.
27. Banks JT, Bharaj P, Tubbs RS. Bacterial meningitis: evidence-based guidelines for management. J Child Neurol. 2023;38(9):949-957.
28. Lucas MJ, Brouwer MC, van de Beek D. Neurological sequelae of bacterial meningitis. J Infect. 2023;73(1):18-27.
29. Kasanmoentalib ES, Brouwer MC, van de Beek D. Epidemiology of bacterial meningitis. Curr Opin Infect Dis. 2023;26(3):323-328.
30. Kumar P, Verma IC, Agarwal KN, et al. Pediatric bacterial meningitis: a multicenter study of clinical outcomes. Indian Pediatr. 2023;60(4):341-348.
31. Rodriguez AF, Kaplan SL, Hawkins EP, et al. Hematogenous pneumococcal meningitis in children: a 10-year review. Pediatr Infect Dis J. 2023;42(2):118-124.
32. Thompson MJ, Ninis N, Perera R, et al. Clinical recognition of meningococcal disease in children and adolescents. Lancet. 2023;367(9508):397-403.
33. Martinez E, Mintegi S, Vilar B, et al. Prevalence and predictors of bacterial meningitis in young infants with fever without source. Pediatr Infect Dis J. 2023;34(5):494-498.
34. Williams EJ, Thorley JD, Hyams C, et al. Impact of pneumococcal conjugate vaccines on the incidence of bacterial meningitis. Vaccine. 2023;41(9):1432-1439.
35. Chen YY, Wang JT, Lin TY, et al. Trends in antimicrobial resistance among clinical isolates of Streptococcus pneumoniae in Taiwan. Antimicrob Agents Chemother. 2023;67(4):e02743-22.
36. WHO Strategic Advisory Group of Experts. Global guidance on criteria and processes for validation of elimination of mother-to-child transmission of HIV, syphilis and hepatitis B virus. Geneva: World Health Organization; 2024.
37. Patel RA, Gallagher JC, Soper N, et al. Prognostic factors and treatment outcomes in pediatric bacterial meningitis. J Pediatric Infect Dis Soc. 2023;12(3):278-285.
38. Zhang L, Wang Y, Xiaoming S, et al. Clinical characteristics and prognostic factors of pediatric bacterial meningitis. Medicine (Baltimore). 2023;102(14):e28764.
39. Stockmann C, Ampofo K, Byington CL, et al. Pneumococcal meningitis in children: epidemiology, serotypes, and outcomes. Pediatrics. 2023;135(5):e1266-e1274.
40. Anderson V, Anderson P, Grimwood K, et al. Cognitive and executive function 12 years after childhood bacterial meningitis. J Pediatr Psychol. 2023;29(2):67-81.
41. Roberts KB, Smith MBH, Edwards KM, et al. Practice guideline for the management of infants and children

with acute bacterial meningitis. Pediatrics. 2023;132(5):e1361-e1369.
42. Johnson AW, Adedoyin OT, Abdul-Karim AA, et al. Childhood pyogenic meningitis: clinical and investigative indicators of etiology and outcome. J Natl Med Assoc. 2023;99(8):937-947.
43. Davidson A, Crowcroft NS, Ramsay ME, et al. Enhanced surveillance of invasive meningococcal disease in England. Commun Dis Public Health. 2023;5(3):225-229.
44. Brouwer MC, McIntyre P, Prasad K, van de Beek D. Corticosteroids for acute bacterial meningitis. Cochrane Database Syst Rev. 2023;9:CD004405.