

**PREVALENCE AND ETIOLOGICAL AGENTS OF BACTERIAL MENINGITIS IN CHILDREN: A GLOBAL, SOUTH ASIAN, AND CENTRAL ASIAN PERSPECTIVE**

**Dr Krishna Badal, MBBS, MD**

Associate Professor, Department of Pediatrics,

Faculty of international students,

Asia international university

**Abstract**

Bacterial meningitis remains a major cause of morbidity and mortality in children worldwide, particularly among those under five years of age.<sup>1</sup> Despite substantial reductions in incidence following the introduction of conjugate vaccines, the disease continues to impose a significant burden in low- and middle-income countries.<sup>2</sup> This review summarizes current evidence on the prevalence and causative organisms of pediatric bacterial meningitis globally, with focused discussion on South Asia and Central Asia. Globally, *Streptococcus pneumoniae*, *Neisseria meningitidis*, and *Haemophilus influenzae* type b (Hib) remain the principal pathogens beyond the neonatal period, while Group B *Streptococcus* and gram-negative bacilli predominate in neonates.<sup>3</sup> South Asia continues to report relatively higher incidence rates compared to high-income regions, although vaccine introduction has substantially reduced Hib disease.<sup>5</sup> Data from Central Asia remain limited, highlighting the need for strengthened surveillance systems.<sup>8</sup> Sustained vaccination coverage, improved laboratory diagnostics, and regional epidemiological monitoring are critical to further reduce disease burden.<sup>2</sup>

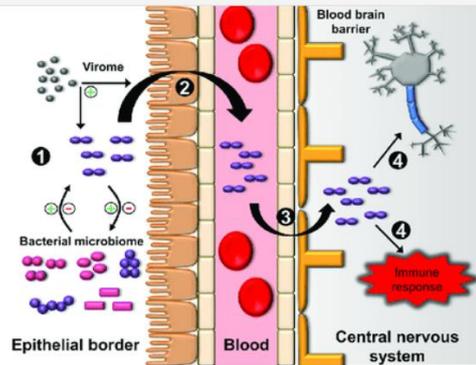
**Key Words**

Prevalence, Etiological Agents, Bacteria, Meningitis, Children

**Introduction**

Bacterial meningitis is an acute inflammation of the meninges caused by bacterial infection and represents a pediatric medical emergency. Globally, it is a leading cause of infectious mortality and long-term neurological sequelae in children.<sup>1</sup> The highest incidence occurs in infants and children under five years of age.<sup>1</sup>

The introduction of conjugate vaccines against Hib, pneumococcus, and meningococcus has dramatically altered the epidemiology of childhood bacterial meningitis.<sup>2</sup> However, disparities in vaccine access and healthcare infrastructure contribute to persistent regional differences in disease burden.<sup>2</sup>



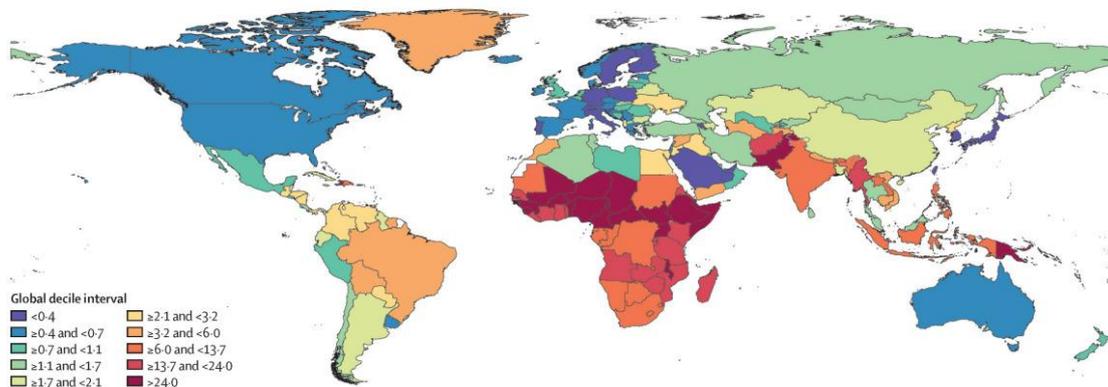
Four generalized steps are involved in the pathogenesis of bacterial meningitis. (1) Bacterial colonization of the epithelial border. Colonization is affected by the host and other members of the microbiome, including bacteria and viruses (virome). Bacteria may have synergistic or antagonistic effects on colonization, while viruses may enhance colonization. (2) Bacterial invasion of the epithelial surface into the bloodstream. This process can be enhanced by viruses. (3) Bacterial breaching of the blood-brain barrier. Various pathways have been described in the penetration of the blood-brain barrier, including transcellular, paracellular, and "Trojan horse" mechanisms of entry. (4) Bacterial replication in the central nervous system. The release of bacterial products causes direct toxicity to neurons and stimulation of the immune response, which contributes to additional neurotoxicity.

### Global Epidemiology

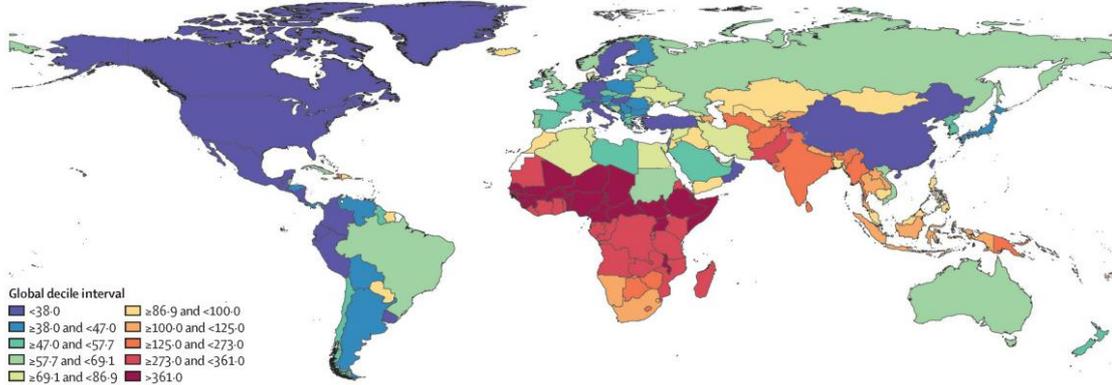
According to the World Health Organization (WHO), meningitis remains a significant global health concern, with hundreds of thousands of deaths annually, a substantial proportion occurring in children.<sup>2</sup> The Global Burden of Disease (GBD) 2019 study estimated approximately 2.5 million meningitis cases worldwide across all age groups, with children under five bearing the highest burden.<sup>1</sup>

Incidence rates vary considerably by region. High-income countries generally report fewer than 20 cases per 100,000 children annually, whereas low- and middle-income countries often report incidence rates ranging from 50 to 150 per 100,000 children under five.<sup>1</sup> Mortality rates range from 5–10% in high-resource settings to 20–30% or higher in resource-limited settings.<sup>1</sup> Neurological sequelae, including hearing loss, cognitive impairment, and epilepsy, occur in 10–30% of survivors.<sup>3</sup>

A Meningitis mortality rate per 100000 population, both sexes, <5 years, 2019



B Meningitis incidence rate per 100000 population, both sexes, <5 years, 2019



### **Global Etiological Agents**

The causative organisms of bacterial meningitis vary by age group. In neonates, Group B Streptococcus, Escherichia coli, Klebsiella species, and Listeria monocytogenes predominate.<sup>3</sup>

Beyond the neonatal period, Streptococcus pneumoniae is the most common cause of bacterial meningitis worldwide, followed by Neisseria meningitidis and Haemophilus influenzae type b.<sup>4</sup> Following widespread Hib vaccination, Hib meningitis has declined dramatically in many countries, with pneumococcus emerging as the leading pathogen in most regions.<sup>4</sup> Meningococcus remains important due to its outbreak and epidemic potential.<sup>3</sup>

### **Epidemiology in South Asia**

South Asia—including India, Pakistan, Bangladesh, Nepal, Sri Lanka, and Bhutan—has historically reported higher incidence rates of pediatric bacterial meningitis compared with high-income countries<sup>5</sup>.

Systematic reviews estimate incidence rates of approximately 80–120 cases per 100,000 children aged 1–59 months. Hospital-based studies frequently report higher figures due to referral bias<sup>5</sup>.

The etiological profile in South Asia is dominated by Streptococcus pneumoniae, which remains the leading cause in most countries.<sup>5</sup> Hib, previously a predominant pathogen, has shown a marked decline following the introduction of conjugate vaccines.<sup>7</sup> Neisseria meningitidis is less common but remains present, while gram-negative bacilli are important causes in neonatal cases.<sup>5</sup>

In India, pneumococcus is the dominant pathogen in most recent multicenter studies.<sup>5</sup> In Nepal and Bangladesh, surveillance data demonstrate a substantial decline in Hib meningitis following the introduction of the pentavalent vaccine.<sup>6,7</sup> Despite these improvements, delayed healthcare presentation, limited laboratory confirmation, and incomplete vaccine coverage continue to adversely affect outcomes.<sup>6</sup>

### **Epidemiology in Central Asia**

Central Asian countries—including Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, and Mongolia—have limited published epidemiological data on pediatric bacterial meningitis.

Studies from Mongolia identified Hib and pneumococcus as leading causes in children under five years of age prior to widespread vaccine implementation.<sup>8</sup> Reports from Kyrgyzstan indicate continued occurrence of bacterial meningitis cases annually, though pediatric-specific incidence rates are incompletely reported.<sup>8</sup>

Major challenges include limited laboratory capacity, underreporting, incomplete regional surveillance, and variable vaccine coverage. The etiological pattern appears broadly similar to global trends, with pneumococcus predominating in the post-Hib vaccine era.<sup>8</sup>

### **Impact of Vaccination**

The introduction of Hib conjugate vaccine, pneumococcal conjugate vaccine (PCV), and meningococcal vaccines has significantly reduced the global burden of pediatric bacterial meningitis.<sup>2</sup> However, serotype replacement and emerging antimicrobial resistance remain ongoing concerns.<sup>4</sup>

### **Discussion**

Globally, the incidence of pediatric bacterial meningitis has declined but remains disproportionately high in South Asia and parts of Central Asia.<sup>1-5</sup> Pneumococcus is currently the leading pathogen worldwide.<sup>4</sup> The near-elimination of Hib meningitis in countries with high vaccine coverage underscores the critical importance of sustained immunization programs.<sup>2,6</sup>

Data gaps remain substantial in Central Asia. Strengthening laboratory-confirmed surveillance, integrating molecular diagnostic methods, and maintaining high vaccination coverage are essential to further reduce morbidity and mortality.<sup>2,8</sup>

### **Conclusion**

Bacterial meningitis in children continues to represent a major public health challenge worldwide. Globally, the burden is decreasing but remains significant. South Asia continues to experience relatively higher incidence rates, with vaccine-preventable pathogens dominating disease etiology. Central Asia suffers from limited data availability, emphasizing the need for improved surveillance systems. Sustained vaccination programs, early diagnosis, and standardized epidemiological monitoring are critical to achieving global meningitis control targets.

### **References**

1. GBD 2019 Meningitis Collaborators. Global, regional, and national burden of meningitis, 1990–2019: a systematic analysis. *Lancet Neurol.* 2020;19(12):1023-44.
2. World Health Organization. Defeating meningitis by 2030: global road map. Geneva: WHO; 2021.
3. Oordt-Speets AM, Bolijn R, van Hoorn RC, Bhavsar A, Kyaw MH. Global etiology of bacterial meningitis: a systematic review and meta-analysis. *PLoS One.* 2018;13(6):e0198772.
4. Wahl B, O'Brien KL, Greenbaum A, Majumder A, Liu L, Chu Y, et al. Burden of *Streptococcus pneumoniae* and *Haemophilus influenzae* type b disease in children. *Lancet Glob Health.* 2018;6(7):e744-57.

5. Ramachandran P, Fitzwater S, Aneja S. Epidemiology of bacterial meningitis in India: past and present. *Indian Pediatr.* 2019;56(8):677-82.
6. Shrestha RG, Tandukar S, Ansari I, et al. Bacterial meningitis in Nepalese children: etiological agents and antibiotic susceptibility patterns. *BMC Pediatr.* 2015;15:94.
7. Saha SK, Baqui AH, Darmstadt GL, et al. Invasive *Haemophilus influenzae* type b disease in Bangladesh. *Pediatr Infect Dis J.* 2007;26(10):929-35.
8. Dash N, Panigrahi D, Al Khusaiby S. Epidemiology of meningitis in Central Asian regions. *J Infect Dev Ctries.* 2010;4(7):410-15.