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# PREVALENCE AND MICROBIAL PROFILE OF CENTRAL NERVOUS SYSTEM INFECTIONS IN PEDIATRIC PATIENTS: A PROSPECTIVE STUDY

Clinical Microbiology

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## ABSTRACT

**Background** :Central nervous system (CNS) infections remain an important cause of morbidity and mortality among pediatric patients, particularly in developing countries. Bacterial, viral, and fungal pathogens contribute significantly to meningitis, encephalitis, and meningoencephalitis, especially among neonates and young children. Early etiological diagnosis is essential for prompt management and improved clinical outcomes. This study aims to determine the microbial profile and prevalence of bacterial, viral, and fungal CNS infections among pediatric patients presenting with suspected CNS infections in a tertiary care hospital. **Materials and Methods:** A prospective cross-sectional study was conducted in the Department of Microbiology, Government Medical College, Amritsar, in collaboration with the Department of Pediatrics, Guru Nanak Dev Hospital, Amritsar, from July 2024 to December 2025. A total of 207 pediatric patients aged 0–15 years with suspected CNS infections were included. Cerebrospinal fluid (CSF) and blood samples were collected and processed using conventional microbiological techniques, culture methods, latex agglutination, and serological assays including enzyme-linked immunosorbent assay (ELISA). **Results** :Among 207 suspected cases, 42 (20.3%) were microbiologically positive for CNS infections. Viral infections were most common (13.04%), followed by bacterial infections (6.7%) and fungal infections (0.5%). Herpes simplex virus (HSV) was the predominant viral pathogen (7.2%), while Escherichia coli was the most common bacterial isolate (2.4%). Candida glabrata was the only fungal isolate detected. Neonates aged 0–1 month represented the largest affected age group. Low birth weight and prematurity were significantly associated with adverse outcomes. Overall mortality was 9.7%. **Conclusion** :Pediatric CNS infections continue to represent a significant clinical challenge due to their diverse microbial etiology. An integrated diagnostic approach combining culture-based methods with serological testing can facilitate early detection, guide appropriate therapy, and potentially reduce morbidity and mortality associated with CNS infections in children.

## KEYWORDS

Central nervous system infections; Pediatric meningitis; Encephalitis; Cerebrospinal fluid; Herpes simplex virus; Escherichia coli; ELISA

## INTRODUCTION

Central nervous system infections are life-threatening conditions involving the brain, spinal cord, meninges, and surrounding structures.[1] These infections include meningitis, encephalitis, meningoencephalitis, ventriculitis, and brain abscesses caused by bacteria, viruses, fungi, parasites, and other microorganisms.[2] Pediatric CNS infections continue to be a major public health concern in developing countries because of high morbidity, mortality, and long-term neurological sequelae. [3] CNS infections are a significant cause of morbidity and mortality in children worldwide, with bacterial meningitis remaining a major health burden, particularly in developing countries.[4,5]

The blood–brain barrier and blood–cerebrospinal fluid barrier provide protection against microbial invasion; however, certain neurotropic pathogens can cross these barriers and cause severe disease.[6] Clinical manifestations vary according to the pathogen and age of the patient. Neonates often present with nonspecific symptoms such as poor feeding, irritability, lethargy, respiratory distress, and seizures, while older children commonly present with fever, headache, neck stiffness, altered sensorium, and focal neurological deficits.[7]

Common bacterial causes of pediatric meningitis include Streptococcus pneumoniae, Neisseria meningitidis, Haemophilus influenzae type b, Group B Streptococcus, Escherichia coli, and Listeria monocytogenes.[8] Viral CNS infections are primarily caused by enteroviruses, HSV, dengue virus, JE virus, VZV, and CMV.[9] Fungal CNS infections are uncommon and usually occur in immunocompromised children.[10] Recent Indian studies indicate a rising predominance of viral etiologies, with HSV emerging as a major cause of pediatric encephalitis and dengue increasingly associated with neurological manifestations.[11–13] Among bacterial pathogens, Gram-negative bacilli such as E. coli and Klebsiella spp. are frequently isolated in neonatal meningitis.[14] Prematurity, low birth weight, prolonged hospitalization, malnutrition, and invasive procedures are important risk factors for CNS infections in children.[15]

Despite advances in vaccination and antimicrobial therapy, CNS infections remain a major cause of morbidity and mortality in children, particularly in resource-limited settings where delayed diagnosis and limited diagnostic facilities hinder effective management.[16–18] Early and accurate diagnosis using conventional methods (Gram stain, CSF analysis, and culture) supplemented by serological and molecular techniques such as ELISA and PCR is essential for appropriate treatment.[19] The epidemiology of pediatric CNS infections varies geographically, and data from Punjab remain limited. Therefore, this study was undertaken to determine the prevalence and microbial profile of bacterial, viral, and fungal CNS infections among pediatric patients, identify bacterial and fungal pathogens from CSF samples, detect viral pathogens serologically, and correlate risk factors with clinico-epidemiological profiles.

## MATERIALS AND METHODS

A prospective cross-sectional study was conducted in the Department of Microbiology, Government Medical College, Amritsar, in collaboration with the Department of Pediatrics, Guru Nanak Dev Hospital, Amritsar, from 1 July 2024 to 31 December 2025.

### Inclusion Criteria

A total of 207 pediatric patients aged 0–15 years presenting with clinical features suggestive of central nervous system infections were enrolled in the study after obtaining informed written consent from their parents or guardians. Assuming a prevalence of CNS infections of 16% in the pediatric population, with a 5% margin of error and 95% confidence interval, the sample size was calculated to be 200 using the formula: $n=(Z\alpha)^2pq/e^2$. Hence, a total of 207 suspected cases of CNS infections were included in the study.

### Exclusion Criteria

Patients above 15 years of age, those receiving specific antibacterial, antifungal, antiviral, antiparasitic therapy, clinically proven cases of CNS infections secondary to head injury, intracranial lesions, cerebrovascular accidents or stroke, and patients whose parents/guardians were unwilling to provide informed consent were excluded from the study.

### Study Procedure

After obtaining informed consent, 2 mL of CSF was collected aseptically by lumbar puncture before initiation of antimicrobial therapy, along with 5 mL of venous blood. All CSF samples were first subjected to cytological examination, including total and differential leukocyte counts, followed by biochemical analysis for glucose and protein estimation. Subsequently, direct microscopic examination was performed along with Gram staining. The CSF specimens were then inoculated for bacterial culture on appropriate culture media and fungal culture on Sabouraud's dextrose agar (SDA). The cytological, biochemical, and microbiological findings were used collectively to

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aid in the diagnosis of CNS infections. Blood samples were centrifuged, and the separated serum was stored at −20°C until testing. Serum samples were analyzed for HSV IgM and IgG (Calbiotech ELISA), Dengue NS1 antigen (Merilisa ELISA), Dengue IgM (NIV Pune kit), and Japanese Encephalitis IgM antibodies (InBios JE Detect™ ELISA) according to the manufacturers' instructions.

**Statistical Analysis**

Data were entered into Microsoft Excel and all statistical analyses were performed using SPSS version 29. Quantitative variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. A p-value <0.05 was considered statistically significant.

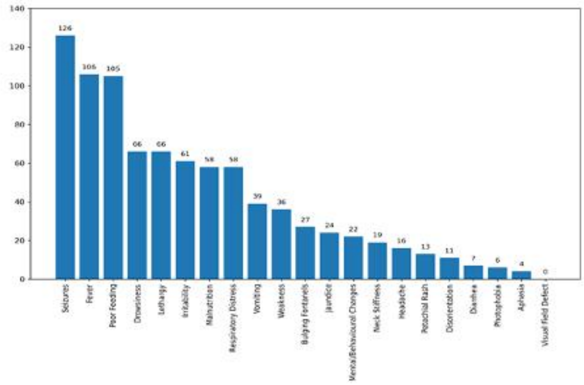
## RESULTS

Out of 207 patients, the majority (104; 50.2%) were aged 0–1 month, indicating that neonates constituted the largest proportion of the study population. The mean age was 1 year 9 months (SD ± 2 years 9 months), although there was considerable variation in age. A total of 122 (58.9%) patients were males and 85 (41.1%) were females, giving a male-to-female ratio of 1.43:1, which indicates a slight male predominance in the study population.

**Table 1: Age-wise and gender distribution of the study population (n=207)**

| Age Group | Male (%) | Female (%) | Total (%) |
|---|---|---|---|
| 0–1 Month | 68 (32.8%) | 36 (17.4%) | 104 (50.2%) |
| 1–3 Month | 6 (2.8%) | 10 (4.8%) | 16 (7.7%) |
| 3 Months–5 Years | 32 (15.5%) | 27 (13.0%) | 59 (28.5%) |
| 5–15 Years | 16 (7.8%) | 12 (5.9%) | 28 (13.5%) |
| Total | 122 (58.9%) | 85 (41.1%) | 207 (100%) |

Rural participants (114) were more than urban (93) overall.




**Graph1: Clinical Presentation of the Study Population (N=207)**

Seizures (60.9%) were the most common clinical presentation, followed by fever (51.2%), poor feeding (50.7%), drowsiness and lethargy (31.9% each), and irritability (29.5%). Other manifestations included respiratory distress, malnutrition, vomiting, weakness, jaundice, and petechial rash.

Lymphocytic predominance (18.4%) was the most common CSF finding, followed by decreased CSF glucose (16.9%) and neutrophilic predominance (12.6%), while eosinophilic predominance was uncommon (1.0%).

Of the 207 cases, 42 were confirmed to have CNS infections, comprising 27 viral, 14 bacterial, and 1 fungal infection, while the remaining cases were negative for the investigated etiological agents.

**Table 2: Distribution of various bacterial ,viral and fungal isolates (n=42)**

| | Method used for identification | Organism | Frequency |
|---|---|---|---|
| Bacterial | Bacterial cultures | Escherichia coli | 5 |
| | | Klebsiella oxytoca | 3 |
| | | Klebsiella pneumoniae | 2 |
| | | Staphylococcus aureus | 1 |
| | | Enterococcus faecalis | 1 |
| | | Streptococcus pyogenes | 1 |
| | | Listeria monocytogenes | 1 |
| Viral | Antibody detection in blood sample by ELISA | Herpes Simplex Virus | 15 |
| | | Dengue Virus | 12 |
| | | Japanese Encephalitis Virus | 0 |
| Fungal | Conventional methods | Candida glabrata | 1 |

Co-infections were uncommon and were identified in only three cases. The co-infecting organisms included Escherichia coli with HSV, Klebsiella oxytoca with Candida glabrata, and Klebsiella pneumoniae with dengue virus, with one case each. These findings indicate that mixed bacterial-viral and bacterial-fungal infections were rare in the study population.

The majority of patients had a favourable outcome, with 187 (90.3%) surviving, while 20 (9.7%) succumbed to the illness.

## DISCUSSION

CNS infections continue to be a major cause of morbidity and mortality among children, particularly in developing countries where factors such as delayed diagnosis, malnutrition, prematurity, and limited healthcare resources adversely affect outcomes. Despite advances in vaccination programs and antimicrobial therapy, CNS infections remain a significant diagnostic and therapeutic challenge in pediatric practice.[20–22]

In the present study, a male predominance was observed (58.9%), with a male-to-female ratio of 1.43:1. Similar observations were reported by Sahu et al.[23] and Patel et al.[24], who documented a higher incidence of CNS infections among male children. The majority of cases belonged to the neonatal age group (0–1 month), indicating the increased vulnerability of neonates to CNS infections. This susceptibility may be attributed to immature immune mechanisms, incomplete development of the blood–brain barrier, and increased exposure to perinatal risk factors.[20,21,25]

Low birth weight, prematurity, and perinatal factors were identified as important risk factors in the present study. Gaschignard et al.[26] and Thaver et al.[27] reported that prematurity and low birth weight significantly increase the risk of neonatal meningitis and sepsis because of impaired host defenses and prolonged hospitalization. In the present study, mortality was significantly associated with birth weight, with all very low birth weight infants demonstrating poor outcomes. These findings emphasize the importance of early recognition and intensive management of high-risk neonates.

The most common clinical manifestations observed were fever, poor feeding, seizures, altered sensorium, irritability, lethargy, and neck stiffness. Similar clinical presentations have been described by Tunkel et al.[28] and Nigrovic et al.[29], who reported that neonatal CNS infections often present with nonspecific symptoms, whereas older children exhibit more classical neurological manifestations. Early identification of these symptoms is essential for timely diagnosis and initiation of appropriate therapy.

Viral pathogens constituted the largest proportion of confirmed CNS infections in the present study. Herpes simplex virus (HSV) was the most frequently detected pathogen, followed by dengue virus. Whitley et al.[30] reported HSV as one of the leading causes of pediatric encephalitis worldwide, supporting the findings of the present study. Dengue-associated CNS infections were also identified, consistent with observations by Solomon et al.[31] and Verma et al.[32], who documented neurological manifestations of dengue infection in endemic regions. No case of Japanese encephalitis was detected during the study period.

Among bacterial pathogens, Gram-negative bacilli predominated. Escherichia coli was the most common bacterial isolate, followed by Klebsiella oxytoca and Klebsiella pneumoniae. Other bacterial isolates included Enterococcus faecalis, Staphylococcus aureus, Streptococcus pyogenes, and Listeria monocytogenes. Similar findings have been reported by Gaschignard et al.[26], Devi et al.[33], and Jayaraman et al.[34], who observed a predominance of Gram-negative organisms in neonatal bacterial meningitis.

HSV (14 cases) and dengue virus (11 cases) were the most common single etiological agents identified. Fungal infection was rare, with only one case involving Candida glabrata in association with bacterial infection. The occurrence of mixed infections highlights the importance of comprehensive microbiological evaluation in suspected CNS infections.

Regarding patient outcomes, the majority of children survived; however, mortality (9.7%) was higher among neonates, low birth

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weight infants, and patients with confirmed CNS infections. The significant association between low birth weight and adverse outcomes underscores the need for early diagnosis, prompt initiation of appropriate antimicrobial therapy, and improved neonatal care practices. Overall, the present study demonstrates that viral pathogens, particularly HSV, are emerging as important causes of pediatric CNS infections, while Gram-negative bacteria continue to be the predominant bacterial pathogens among neonates and young infants.

## CONCLUSION

In conclusion, the present study highlights that viral pathogens, particularly HSV, were the predominant cause of pediatric CNS infections, while E. coli and Klebsiella species were the leading bacterial isolates. Neonates, preterm infants, and low birth weight babies were at greater risk of CNS infections and adverse outcomes. Although conventional microbiological methods remain essential for diagnosis, serological methods such as ELISA improved detection of viral pathogens in resource-limited settings. The study emphasizes the importance of strengthening diagnostic facilities and implementing region-specific surveillance strategies.

Early diagnosis, improved laboratory infrastructure, timely anti-microbial therapy, and strengthened vaccination programs are essential to reduce morbidity ,mortality and improve clinical outcomes associated with pediatric CNS infections.

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