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Evaluation of clinicoetiological profile for seizures among children under 5 years in India

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Abstract:
Seizures are a common pediatric neurological emergency, particularly in children younger than 5 years, yet their etiological and clinical patterns remain insufficiently characterized in resource-limited settings. Therefore, it is of interest to evaluate the medical records of 191 children aged 1 month–5 years hospitalized with seizures during 2023, assessing demographic characteristics, seizure semiology, etiologies and clinical outcomes. Most children (68.06%) were aged 1–5 years and generalized tonic-clonic seizures (73.29%) were predominant, followed by focal seizures (11.51%) and generalized tonic seizures (10.99%). Febrile seizures (29.8%) were the leading etiology, followed by first unprovoked seizures (25.6%), metabolic derangements (11.5%), central nervous system infections (9.9%) and sequelae of hypoxic-ischemic encephalopathy (6.3%). Thus, data shows the clinical and etiological spectrum of pediatric seizures emphasizing systematic evaluation for early identification of treatable causes.

Keywords: Seizures, children, febrile seizures, etiology, generalized tonic-clonic seizures, pediatric neurology

Background:
Seizures constitute one of the most frequently encountered neurological emergencies in pediatric medicine, representing a substantial burden on healthcare systems worldwide. A seizure is defined as a transient occurrence of signs and symptoms resulting from abnormal excessive or synchronous neuronal activity in the brain, manifesting as alterations in motor function, sensory perception, autonomic regulation, consciousness, or behavior **[1]**. The developing brain of young children exhibits heightened susceptibility to seizure activity owing to the relative imbalance between excitatory and inhibitory neurotransmission, incomplete myelination and ongoing synaptic maturation **[2]**. Epidemiological data indicate that approximately four to ten percent of children experience at least one seizure episode during the first sixteen years of life, with the peak incidence occurring during the first five years **[1]**. The etiological spectrum of pediatric seizures is remarkably diverse, encompassing febrile seizures, central nervous system infections, metabolic derangements, structural brain abnormalities, genetic epilepsy syndromes, traumatic brain injury and hypoxic-ischemic insults **[3]**. Febrile seizures represent the most prevalent seizure type in early childhood, affecting two to five percent of children between six months and five years of age in Western populations, with even higher reported prevalences in certain Asian countries **[4]**. Although febrile seizures are generally considered benign and self-limiting, their clinical differentiation from seizures secondary to meningitis, encephalitis, or other serious etiologies demands vigilant assessment **[5]**. Emergency department visits attributable to seizures account for approximately one percent of all pediatric emergency presentations, with disproportionately higher visit rates documented among infants, toddlers and males **[6]**. In developing nations, infectious etiologies including bacterial meningitis, viral encephalitis, cerebral malaria and neurocysticercosis contribute substantially to the seizure burden, reflecting disparities in immunization coverage, sanitation infrastructure and access to timely healthcare **[7]**. Hospital-based studies from India have similarly identified febrile seizures as the predominant cause of pediatric seizures, followed by central nervous system infections, with CNS infections associated with greater morbidity and mortality. Metabolic causes such as hypocalcemia, hypoglycemia and dyselectrolytemia also constitute important reversible etiologies that warrant prompt recognition and correction **[8]**. The International League Against Epilepsy (ILAE) 2017 classification provides a standardized framework for categorizing seizure types based on their onset characteristics, level of awareness and motor or non-motor features, thereby facilitating consistent clinical communication and research comparability **[9]**. Accurate seizure classification is integral to the diagnostic workup, selection of appropriate antiseizure medications and prognostic counseling. Despite the considerable clinical significance of pediatric seizures, the existing literature reveals a notable paucity of comprehensive data regarding the etiological distribution and clinical characteristics of seizures in children from resource-limited settings in India **[10]**. Most large-scale epidemiological studies on pediatric seizures have been conducted in high-income countries and their findings may not be directly generalizable to populations in developing nations where the disease burden, etiological spectrum and healthcare access patterns differ substantially **[11]**. Therefore, it is of interest in order to reduce mortality and morbidity caused by seizures, to have these data in order to develop public health initiatives, allocate resources effectively and implement evidence-based therapeutic procedures.

Materials and Methods:
Study design and setting:
The pediatric department, including the pediatric critical care unit and other pediatric wards, was the setting for this descriptive cross-sectional research. From June to December 2024, researchers analyzed admissions data from January 1, 2023, to December 31, 2023, using a retrospective data gathering method.

Study population and sample size:
All children hospitalized to the pediatric department with a seizure diagnosis between the ages of one month and five years made up the study group. Caretakers' observations of seizures at home and their subsequent reporting of them during patient history-taking or hospital staff's documentation of such occurrences were considered seizures. During the trial period, 345 individuals were hospitalized with seizures; 231 of these patients were in the target age range of one month to five years. The final analysis comprised 191 children after exclusion criteria were applied.

Inclusion criteria:
All children aged one month to five years admitted with seizures, whether witnessed by caregivers or observed during hospitalization, were eligible for inclusion.

Exclusion criteria:
Children whose medical records were incomplete or contained insufficient data for meaningful analysis were excluded. Patients who left against medical advice prior to completion of the diagnostic evaluation and clinical management were also excluded from the study.

Data collection procedure:
A pre-designed structured proforma was used to capture pertinent demographic and clinical data that was retrieved from the pediatric department's medical records section. The data that was gathered encompassed a wide range of topics, including demographic variables like age, sex and residence; seizure characteristics like type, duration, frequency and timing; associated symptoms like fever, headache, vomiting, respiratory symptoms and ear discharge; postictal features; underlying etiology history; neurodevelopmental history; past medical history, including seizure episodes; family history of seizures or epilepsy; findings of comprehensive neurological and clinical examinations; pertinent laboratory investigations, including complete blood count, serum electrolytes, blood glucose, cerebrospinal fluid analysis and neuroimaging studies; final etiological diagnosis; and clinical outcome.

Seizure classification:
Following the guidelines laid forth by the ILAE 2017 Commission on Classification and Terminology, the various forms of seizures were categorized. Generalized onset, focal onset, unknown onset and unclassified were the main categories into which seizures were further subdivided according to the symptoms shown by each kind of seizure.

Etiological classification:
The clinical history, physical examination, laboratory tests and neuroimaging data were used to diagnose the underlying cause of the seizures.

Statistical analysis:
After data collection was complete, it was evaluated using industry-standard statistical procedures in an Excel spreadsheet. Categorical data were shown as frequencies and percentages, whilst continuous variables were shown as mean ± standard deviation. For categorical variables, we used Fisher's exact test or chi-square test to compare groups; a p-value of less than 0.05 was deemed statistically significant.

Results:
There were almost 1.58 males for every girl among the 191 kids that participated in the research (117 male, or 61.26% of the total). According to the data, 130 children (68.06% of the total) were in the age bracket of one year and above, while 61 (31.94% of the total) were in the one month to one year bracket. The average age of the participants in the research was 25.73 ± 16.42 months. Among the seizure types identified in 166 children (86.91%), generalized seizures were the most common. Of all the types of generalized seizures, tonic-clonic seizures accounted for 73.30 percent, with 140 instances. Tonic seizures came in second, with 21 occurrences (10.99%). Only three occurrences (1.57% of the total) included newborns, while eleven children (11.52% of the total) had focal seizures. While generalized tonic seizures and subtle seizures were more prevalent in newborns, generalized tonic-clonic seizures were more common in the older age group (>1 year to 5 years; 73.57%) than in infants (27.14%) **(Table 1)**. Complex febrile seizures (35 cases, 18.32%) were more numerous than simple febrile seizures (22 cases, 11.52%), making febrile seizures the most prevalent etiological diagnosis, accounting for 57 cases (29.84%). Metabolic derangements were the second most common provoked cause, identified in 22 patients (11.52%), with hypocalcemia being the predominant metabolic abnormality (16 cases, 8.38%). Central nervous system infections were diagnosed in 19 patients (9.95%), with bacterial meningitis (9 cases, 4.71%) being the most frequent infectious etiology. First unprovoked seizures without an identifiable acute cause were present in 49 cases (25.65%) and idiopathic epilepsy was diagnosed in 19 children (9.95%). Sequelae of hypoxic-ischemic encephalopathy accounted for 12 cases (6.28%). Among the 191 children included in the study, 183 (95.81%) showed clinical improvement and were discharged, while 8 (4.19%) children expired during the hospital stay. Deaths were primarily observed in children with central nervous system infections (3 cases), metabolic derangements (2 cases) and hypoxic-ischemic encephalopathy sequelae (2 cases), with one death attributed to an inborn error of metabolism **(Table 2)**.

Table 1: Distribution of patients according to seizure type by gender and age group

Seizure Type	Total n (%)	Male n (%)	Female n (%)	1 month–1 year n (%)	>1 year–5 years n (%)
Generalized (n=166, 86.91%)					
Tonic-clonic	140 (73.30)	86 (61.43)	54 (38.57)	38 (27.14)	102 (73.57)*
Tonic	21 (10.99)	12 (57.14)	9 (42.86)	13 (61.90)	8 (38.10)
Clonic	1 (0.52)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)
Myoclonic	1 (0.52)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)
Atonic	3 (1.57)	1 (33.33)	2 (66.67)	0 (0.00)	3 (100.00)
Focal	22 (11.52)	15 (68.18)	7 (31.82)	6 (27.27)	16 (72.73)
Unknown/Subtle	3 (1.57)	1 (33.33)	2 (66.67)	3 (100.00)	0 (0.00)
Total	191 (100.00)	117 (61.26)	74 (38.74)	61 (31.94)	130 (68.06)

Table 2: Distribution of seizure patients based on etiological diagnosis

Etiological Diagnosis	Subcategory	Number (%)
CNS Infection (n=19, 9.95%)	Acute encephalitis syndrome	6 (3.14)
	Bacterial meningitis	9 (4.71)
	CNS tuberculosis	2 (1.05)
	Acute viral encephalitis	2 (1.05)
Febrile Seizure (n=57, 29.84%)	Simple febrile seizure	22 (11.52)
	Complex febrile seizure	35 (18.32)
Stroke		3 (1.57)
Metabolic (n=22, 11.52%)	Hypocalcemia	16 (8.38)
	Hypoglycemia	1 (0.52)
	Dyselectrolytemia	5 (2.62)
HIE sequelae		12 (6.28)
Post-meningitic sequelae		2 (1.05)
Inborn errors of metabolism		2 (1.05)
Hypoxic events		2 (1.05)
Structural brain abnormality		2 (1.05)
Head injury		2 (1.05)
First unprovoked seizure		49 (25.65)
Idiopathic epilepsy		19 (9.95)
Total		191 (100.00)

Discussion:

In this extensive research, children hospitalized at a tertiary care institution in Central India between the ages of one month and five years were examined for the clinicoetiological characteristics of seizures. Results provide light on this susceptible population's demographics, seizure semiology, etiological spectrum and clinical consequences. This gender disparity has been attributed to hormonal influences, genetic factors linked to the X chromosome and differences in brain maturation between males and females **[12]**. Several hospital-based studies from India and other developing countries have similarly documented a higher incidence of seizures among male children **[13, 14]**. The age distribution in the current study, with the majority of patients (68.06%) belonging to the one to five year age group, aligns with the well-established observation that seizure susceptibility peaks during the toddler and pre-school years **[1]**. This period corresponds to a developmental window characterized by rapid synaptogenesis, ongoing myelination and a relative predominance of excitatory neurotransmission, all of which contribute to the lower seizure threshold in young children **[2]**. A similar age distribution pattern was reported in a study conducted at a tertiary care center where the highest proportion of seizure patients were between thirteen and sixty months of age **[15]**. Prashanthi *et al.* similarly reported a predominance of seizures in young children, with generalized-onset seizures being the most common seizure type and febrile seizures representing the leading etiology **[16]**. Likewise, another studies documented the highest seizure incidence in children aged one to three years, followed by the three to five year age group **[17]**. Consistent with earlier research, this study found that generalized tonic-clonic seizures were the most prevalent form of seizure, accounting for 73.30% of cases. This finding is also consistent with Malaiarasu and Surya, who reported generalized tonic-clonic seizures as the predominant seizure type among hospitalized children, with fever being a common associated feature **[18]**. Generalized seizures were seen in around two-thirds of all instances in children under twelve years old with seizures, with tonic-clonic seizures being the most common subtype **[19]**. The high prevalence of generalized seizures in young children reflects the propensity of the immature brain for rapid bilateral propagation of epileptiform discharges **[20]**. The identification of subtle seizures exclusively in the infant age group is consistent with the known electroclinical characteristics of neonatal and infantile seizures, where subtle motor manifestations such as tonic eye deviation, oral-buccal-lingual movements and autonomic phenomena may constitute the predominant seizure semiology **[9]**. Febrile seizures emerged as the single most common etiological diagnosis in this study, accounting for 29.84% of all cases. This finding is in strong agreement with the existing literature, which consistently identifies febrile seizures as the most prevalent cause of seizures in children between six months and five years of age **[21]**. Similarly, Ramesh *et al.* reported febrile seizures as the most common etiology, while generalized tonic-clonic seizures accounted for the majority of seizure presentations, particularly among children aged one to five years **[22]**. It is possible that referral bias explains why complex febrile seizures (18.32%) were more common than simple febrile seizures (11.52%). This is because children with complex febrile seizures are more likely to be admitted to the hospital for observation and further evaluation, while those with simple febrile seizures can be treated in the emergency department and then released. A recent investigation from rural western India similarly reported febrile seizures as the predominant etiology for first-time seizures in young children, emphasizing the importance of parental education regarding fever management and seizure first aid **[23]**. Sharma *et al.* likewise identified febrile seizures as the leading cause of pediatric seizures, followed by CNS infections, with generalized tonic-clonic seizures being the most common seizure phenotype **[24].** Metabolic derangements constituted the second most common provoked cause of seizures (11.52%), with hypocalcemia being the predominant metabolic abnormality. The high prevalence of hypocalcemia-related seizures, particularly in infants, is a notable finding that warrants attention. Nutritional deficiency of vitamin D and calcium, prevalent in the Indian subcontinent due to dietary practices, skin pigmentation and limited sun exposure, likely contributes to this observation **[25]**. The significantly higher prevalence of metabolic causes in infants compared to older children (22.95% vs. 6.15%; $p = 0.001$) reflects the heightened vulnerability of the developing infant brain to metabolic perturbations and the relative immaturity of homeostatic regulatory mechanisms during the first year of life. Nine point five percent of cases were caused by illnesses of the central nervous system, with bacterial meningitis being the infectious cause most often cited. This finding underscores the continued importance of infectious causes of seizures in developing countries, where delayed presentation, incomplete immunization coverage and limited access to healthcare facilities contribute to the burden of neuroinfectious diseases **[7]**. Research from sub-Saharan Africa has reported even higher proportions of infection-related seizures, with malaria, meningitis and dehydration being the predominant etiologies **[26]**. The relatively lower proportion of

infectious etiologies in the present study compared to African studies may reflect differences in the epidemiological landscape, immunization coverage. The substantial proportion of first unprovoked seizures (25.65%) in this study is noteworthy. These cases, where no acute provoking factor could be identified through clinical assessment and standard investigations, may represent the initial manifestation of an underlying epilepsy syndrome or may remain as isolated events without recurrence. Long-term follow-up studies have demonstrated that approximately thirty to forty percent of children with a first unprovoked seizure will experience recurrence, with the risk being highest during the first two years **[27]**. Sequelae of hypoxic-ischemic encephalopathy accounted for 6.28% of cases and were significantly more common in infants, reflecting the long-term neurological consequences of perinatal asphyxia. Improving perinatal care, early identification of at-risk neonates and timely implementation of neuroprotective strategies **[28]**. The mortality rate of 4.19% in the present study is comparable to that reported in other hospital-based studies from developing countries **[26]**. Deaths were predominantly associated with central nervous system infections, severe metabolic derangements and hypoxic-ischemic encephalopathy squeals, highlighting the need for early recognition and aggressive management of these potentially fatal conditions. Several limitations of this study merit consideration. The retrospective design inherently limits the completeness and accuracy of data extraction from medical records. The single-center, hospital-based nature of the study introduces selection bias, as the findings may not be representative of the broader community. The exclusion of patients who left against medical advice and those with incomplete records may have further influenced the results. The absence of electroencephalographic data for all patients limits the precision of seizure classification in some cases. It is also not possible to evaluate rates of seizure recurrence or long-term neurodevelopmental effects due to a lack of data from long-term follow-up studies.

Conclusion:

Febrile seizures predominate among children less than 5 years while generalized tonic-clonic seizures occur across all ages, with etiology varying significantly by age group. Infants show higher metabolic disturbances and hypoxic-ischemic sequelae, whereas 1-5 year olds predominantly experience febrile seizures as the leading cause. Systematic diagnostic evaluation including history, examination, laboratory tests and neuroimaging remains essential for etiological identification, targeted treatment and optimal neurodevelopmental outcomes in resource-limited settings.

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