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Spectrum of Neurological Diseases in the Pediatric Intensive Care Unit of the Largest Tertiary Children's Hospital in Sindh, Pakistan

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ABSTRACT

Background: Pediatric neurological disorders contribute significantly to morbidity and mortality, particularly in developing countries where data on their prevalence and outcomes is limited. This study aims to characterize the clinical profile and outcomes of children with neurological illness admitted to a pediatric intensive care unit (PICU) in Pakistan. **Methods:** This was a prospective, single-center study conducted from December 2024 to May 2025 at the PICU of the National Institute of Child Health, Karachi. Children aged 1 month to 16 years with a primary neurological diagnosis were included. Data on demographics, diagnosis (categorized by ICD-9), resource utilization (e.g., mechanical ventilation), and outcomes (survival, length of stay) were collected. Descriptive statistics and bivariate analysis were performed. **Results:** Of 465 total PICU admissions, 94 (20.22%) had a primary neurological diagnosis. The mean age was 4.92 ± 3.79 years, with a male predominance (63.8%). Infectious/Inflammatory disorders were the most common diagnosis (66.0%), followed by Neuromuscular diseases (17.0%). The overall mortality rate was 47.9%. A high proportion of patients required mechanical ventilation (90.4%), which was significantly associated with mortality (P=0.020). The mean PICU length of stay was 10.03 ± 7.36 days. Lumbar puncture was performed in 73.4% and MRI in 54.3% of patients, while EEG utilization was low (6.4%). **Conclusion:** Primary neurological illness accounts for a substantial proportion of PICU admissions in this setting and is associated with an alarmingly high mortality rate, primarily driven by infectious etiologies. The need for mechanical ventilation serves as a key predictor of poor outcome. These findings highlight the urgent need for enhanced public health interventions to prevent CNS infections and improved neurocritical care infrastructure and training to reduce mortality and morbidity in this vulnerable population.

INTRODUCTION

Neurological disorders in pediatric population represents a significant global health challenge, contributing majorly to mortality and morbidity in children (1). This burden is particularly pronounced in developing countries, where there is resource limitations, seeking care is often delayed, and inadequate access to specialized care intensify disease outcomes (2). In such situations, Pediatric Intensive Care Units (PICUs) serve as critical points of care for severely ill children particularly with neurological conditions (3). However, a significant knowledge gap persists, with a notable lack of epidemiological data on the prevalence, characteristics, and outcomes of neurological disorders in children from developing countries, including Pakistan. The absence of comprehensive local data hampers effective policy planning, resource allocation, and the development of targeted interventions.

There is a high mortality burden associated with neurological diseases in a PICU setting, and even with those who survive, these conditions often lead to long-term neurodevelopmental disabilities and a lifelong need for rehabilitative care (4, 5). An understanding into the profiles of these patients and their clinical presentations is crucial for improving patient management and predicting outcomes. This study aims to address the data deficit by analyzing the clinical characteristics and outcomes of children neurological disorders admitted to a PICU in Pakistan along with the burden of diseases. Our objective is to provide local evidence that will help make informed clinical practice alterations, guide new institutional policies, and ultimately contribute to reducing the significant morbidity and mortality burden of neurological diseases in the region.

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METHODS

Study Design and Setting

This was a prospective, single-center study conducted at the Pediatric Intensive Care Unit (PICU) of the National Institute of Child Health (NICH) in Karachi, Pakistan. NICH is the largest children's hospital in the country and has a 13-bed PICU that serves as a tertiary referral center for pediatric patients with critical illnesses. The data was collected from December 2024 to May 2025. The study protocol was reviewed and approved by the institutional ethical review board (IERB# 37-19).

Study Population

All children aged 1 month to 16 years admitted to the PICU with a primary diagnosis of a neurological illness were included in the study. Patients with non-neurological primary diagnoses or those admitted for routine postoperative observation for non-neurosurgical procedures were excluded.

Data Collection

A structured data collection proforma was used to record basic demographic information, including age and gender. Detailed clinical data were collected, comprising primary neurological diagnosis, clinical course, need for mechanical ventilation, and use of inotropic support. Outcomes were recorded as survival/expired and length of stay (LOS).

Neurological diagnoses were categorized using the International Classification of Diseases, 9th Revision (ICD-9) coding system. Based on clinical evaluation, laboratory investigations, and neurodiagnostic tests (CT/MRI brain, EEG, EMG/NCS, lumbar puncture), diagnoses were grouped into the following categories: Structural/Neurosurgical (Traumatic brain injury, CNS tumors, Congenital structural anomalies), Infectious/Inflammatory (CNS infections, Autoimmune disorders), Neurodegenerative/Metabolic (Demyelinating and neurodegenerative disorders, Metabolic disorders, Toxic encephalopathies), Vascular/Seizure-related (Stroke, Status epilepticus), and Neuromuscular diseases (Neuromuscular disorders, Guillain-Barré syndrome, myasthenia gravis).

Statistical Analysis

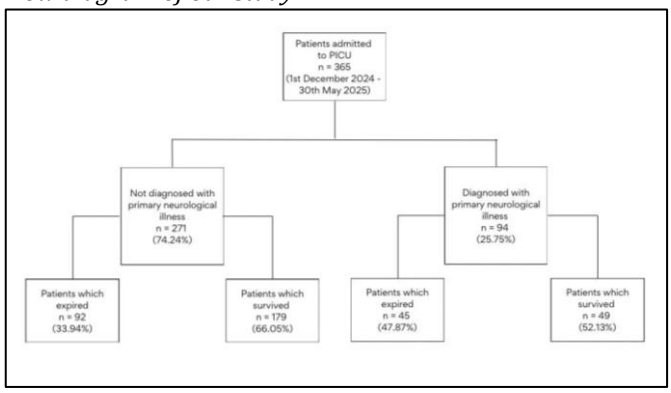
Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. Appropriate analytical tests were applied to investigate associations between clinical variables and patient outcomes.

RESULTS

During the study period, a total of 365 patients were admitted to the PICU, of whom a total of 94 (25.75%) were diagnosed as having a primary neurological illness (Figure 1).

Figure 1

Flow diagram of our study



The mean age of the patients was 4.92 ± 3.79 years, with the patients age ranging between 2 months to 13 years. In terms of gender distribution, majority (63.8%) were male patients. Out of the 94 patients, 45 (47.9%) expired during the hospital stay (Table 1).

Table 1

Demographics, outcome, and PICU length of stay of our population

Characteristics	n (%)
Total	365 (100)
Gender	
Male	60 (63.8)
Female	34 (36.2)
Age	
Mean ± Standard deviation (years)	4.92 ± 3.79
<5	48 ()
5-10	38 ()
>10	8 ()
Outcome	
Survival (Step down)	49 (52.1)
Mortality (Expired)	45 (47.9)
PICU Length of Stay	
Mean ± Standard deviation (days)	10.03±7.36
Range (days)	1–28

The most frequent diagnostic categories among the neurological patients were Infectious/Inflammatory, which included CNS infections (n=61), autoimmune disorders (n=1), and others, and comprised a total of (n= 62, 66.0%). Neuromuscular diseases represented (n= 16, 17.0%). Furthermore, Neurodegenerative/Metabolic disorder accounted for (n=9, 9.6%), including metabolic disorders (n=6), demyelinating/ neurodegenerative disorders (n=2), and toxic encephalopathies (n=1). Structural/Neurosurgical cases constituted (n= 5, 5.3%), with diagnoses including traumatic brain injury (n=3), CNS tumors (n=1), and congenital structural anomalies (n=1). The remaining patients were classified under vascular/seizure-related and included stroke (n=1) and status epilepticus (n=1) (Table 2).

The mean PICU length of stay for the entire cohort was 10.03 ± 7.36 days and ranged from between 1 day to 28 days. The overall mortality rate was 47.9% (n=45). Of the patients who survived (Table 1). In regard to ICU resource utilization, 90.4% (n=85) of the patients with a primary neurological illness required mechanical ventilation, out of which 21.2% (n=18) underwent a tracheostomy (Table 3).

A range of neurodiagnostic procedures were performed on the cohort including lumbar puncture, which was carried out in 73.4% (n=69), CT scan in 13.8%

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(n=13), and MRI brain/spine in 54.3% (n=51) of patients (Table 3). Specialized laboratory and neurophysiological testing included viral panel 9.6% (n=9), CSF GeneXpert 10.6% (n=10), nerve conduction studies (NCS) in 18.1% (n=17), and EEG in 6.4% (n=6). In terms of therapeutic interventions, steroids were administered to 17.0% (n=16) patients, plasmapheresis to 11.7% (n=11), and Intravenous Immunoglobulin (IVIG) to 9.6% (n=9) patients. Furthermore, neurosurgical procedures included external ventricular drain (EVD) placement in 4.3% (n=4) patients and ventriculoperitoneal (VP) shunt insertion in 1.1% (n=1) of the cohort.

Table 3

Breakdown of patients on basis of diagnostic category and mortality

Diagnostic Category	Sub-Diagnosis Breakdown	n (%)	Mortality n (%)
Infectious/ Inflammatory	CNS infections, autoimmune disorders, and others	62 (66.0)	34 (54.8)
	- CNS infections	61	34
	- Autoimmune disorders	1	0
Neuromuscular Diseases	(Guillain-Barré, Myasthenia Gravis, etc.)	16 (17.0)	6
Neurodegenerative/ Metabolic	Metabolic, Demyelinating, and Toxic Encephalopathies	9 (9.6)	3 (33.3)
	- Metabolic disorders	6	2
	- Demyelinating/Neurodegenerative	2	1
	- Toxic encephalopathies	1	0
Structural/ Neurosurgical	Traumatic brain injury, CNS tumors, Congenital structural anomalies	5 (5.3)	0 (0)
	- Traumatic brain injury	3	0
	- CNS tumors	1	0
	- Congenital structural anomalies	1	0
Vascular/ Seizure-related	Stroke and Status epilepticus	2 (2.1)	2 (100)
	- Stroke	1	1
	- Status epilepticus	1	1
Total		94 (100)	
Diagnostic Category	**Sub-Diagnosis Breakdown**	**n (%)**	**Mortality n (%)**
Infectious/ Inflammatory	CNS infections, autoimmune disorders, and others	62 (66.0)	34 (54.8)

Table 4

Procedures and interventions performed during the PICU stay

Procedure / Intervention Category	n (%)
Critical Care Support	
Mechanical Ventilation Required	85 (90.4)
Tracheostomy	18 (19.1)
Neurodiagnostic Procedures	
Lumbar Puncture (LP)	69 (73.4)
MRI Brain/Spine	51 (54.3)
CT Scan	13 (13.8)
Specialized Testing	
Nerve Conduction Studies (NCS)	17 (18.1)
CSF GeneXpert	10 (10.6)
Viral Panel	9 (9.6)
Electroencephalography (EEG)	6 (6.4)
Therapeutic Interventions	
Steroids Administered	16 (17.0)
Plasmapheresis	11 (11.7)
Intravenous Immunoglobulin (IVIG)	9 (9.6)
Neurosurgical Procedures	
External Ventricular Drain (EVD) Placement	4 (4.3)
Ventriculoperitoneal (VP) Shunt Insertion	1 (1.1)

Bivariate analysis demonstrated that mechanical ventilation was significantly associated with mortality (P=0.020). Furthermore, the Length of Stay showed a marginal association with patient outcome (P=0.050). The two-sample t-test comparing the mean length of stay between survivors and non-survivors was near the significance threshold (P=0.051). No significant association was found between the patient outcome and the use of steroids, IVIG, plasmapheresis, or need for tracheostomy (P>0.05 for all) (Table 4).

Table 5

Statistical analyses performed on the variables

Factor Tested	Type of Test	P-value	Interpretation
Mechanical Ventilation	Bivariate Analysis (e.g., Chi-square or Fisher's Exact)	**0.020**	Statistically Significant Association with Mortality (P < 0.05).
Categorized Length of Stay	Bivariate Analysis (e.g., Chi-square)	**0.050**	Marginally Significant Association with Patient Outcome.
Mean Length of Stay (Survivors vs. Non-Survivors)	Two-sample t-test	**0.051**	Near Significance (Trend); Non-survivors tended to have a longer LOS.
Steroids Use	Bivariate Analysis	>0.05	No Significant Association with Patient Outcome.
IVIG Use	Bivariate Analysis	>0.05	No Significant Association with Patient Outcome.
Plasmapheresis Use	Bivariate Analysis	>0.05	No Significant Association with Patient Outcome.
Tracheostomy Need	Bivariate Analysis	>0.05	No Significant Association with Patient Outcome.

DISCUSSION

Our prospective study provides important perspective on the profile, resource utilization, and outcomes of children admitted to the PICU with a primary neurological illness in a lower-middle income country (LMIC). The findings show a high epidemiological burden along with a high mortality associated with such conditions in setting of a developing country.

As per our literature review, we were only able to find a single study from 2014 from Pakistan which have looked into the spectrum of neurological diseases in pediatric population admitted in the PICU (3). Neurological illnesses

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have always made a considerable chunk of PICU admissions globally second to respiratory causes only (6-8). In our study, we also see neurological illness accounting for 25.75% of all PICU admissions highlighting it as a significant cause of critical illness in this population, consistent with the growing global recognition. Neurological diseases have always contributed to a longer length of stay (LOS) in PICU and with increased cost of hospital (8, 9), similar finding was seen in our study with a 10.03 day mean PICU stay.

Our study reported an overwhelming predominance of Infectious/Inflammatory disorders, which accounted for 66.0% of all neurological admissions, primarily driven by CNS infections (n=61). This starkly contrasts with literature from high-income countries, where the primary neurological diagnoses in PICUs are often seizure-related or trauma-related brain injury (6, 7). The high frequency of infections reflects the substantial public health challenges in Pakistan, including limited access to primary vaccination, delayed presentation, and prevalence of infectious diseases that result in severe central nervous system compromise. Conversely, the rate of Structural/Neurosurgical admissions, including traumatic brain injury, in our study population was notably low at 5.3%. This figure may be influenced by the PICU's referral patterns as NICH mainly functions as a medical center, however it still differs significantly from the higher trauma rates commonly reported globally.

While our analysis showed no apparent significant association between the category of neurological illness diagnoses and mortality, the p-value was just on the border (P=0.051) suggesting a potential association could exist. Out of the 62 patients who were admitted with infectious/inflammatory neurological illnesses, 54.8% (n=34) expired. This is similar to published literature which has showed mortality in CNS infections to be similar (4, 6). Mortality rates in neuromuscular diseases was 37.5% followed by neurodegenerative/metabolic conditions which was 33.3%. Our study also found that 100% (n=2) of patients with seizure-related disorder/vascular disorder expired, whereas 100% (n=2) of patients with structural/neurosurgical disease survived. However, this data set is too minute to make an observation.

The most critical result is the mortality rate of neurological patients in PICU which came out to be 47.9% (n=45), whereas the overall mortality percentage of patients in PICU was 33.9%. This rate is substantially higher than most international reports from pediatric intensive care units, which typically range between 10% and 20% for neurological cohorts (5). The rates are quite elevated even when compared to PICU settings in similar developing countries, which range between 15% and 25% (3, 5, 10), on the other hand a study from Egypt for 100 consecutive patients showed a mortality rate of 50% which is slightly higher than the rate seen in our study (11). However, Moreau et al. in 2013 reported a similar figure of 46.2% mortality rate for PICU patients with a neurological disorder across 11 state hospitals in United States (8). This elevated mortality in our study signifies the severity of illness at the time of admission, likely compounded by delayed transport, resource limitations, and advanced disease progression, often seen in the context of developing healthcare systems. NICH being a public hospital is often subjected as a last resort and receives most critical patient referrals. This finding highlights the urgent need for enhanced care strategies and public health interventions to improve outcomes for these vulnerable patients.

The association between mechanical ventilation and mortality was statistically significant (P=0.020), which reinforces the critical nature of the patients in our study. The need for respiratory support is a direct representation for severe neurological compromise i.e., loss of gag reflex (loss of airway protective reflexes), central hypoventilation due to brainstem involvement, etc. and is thus a well-established predictor of poor outcome in neurocritical care (5, 12, 13). Furthermore, the length of stay demonstrated a marginal association with outcome (P=0.050) and was near the significance threshold in the t-test (P=0.051). This suggests that non-survivors tended to have longer PICU stay, reflecting prolonged dependence on critical care resources before death (14, 15).

The high utilization rates of Lumbar Puncture (73.4%) and MRI brain/spine (54.3%) are commendable and indicate the commitment of the clinical team to definitive etiological diagnosis via advanced diagnostic modalities. It also indicates the severity of the conditions of the patients in our cohort. However, the relatively low utilization of EEG (6.4%) and other specialized neurophysiological tests (NCS 18.1%) could be attributed to resource-limitations of specialized upcoming technology, which is crucial for optimal neurocritical care management. CT scans and MRI are readily available, however the technology used in EEG and EMG-NCS is still relatively new in Pakistan with limited equipment available in public hospitals as a result they are less utilized. At times any fault in these equipment can put the machine out of commission for months.

In terms of therapeutic interventions, no significant association was found between the use of specific immune-modulating therapies (steroids, IVIG, plasmapheresis) and patient outcome. This lack of association may be due to the small sample size for these specific interventions, or the overwhelming severity of the underlying infections, which may mask any potential treatment benefit from these therapies.

This study possesses several important strengths. Being a prospective study, it minimized recall bias and allowed for the meticulous and real-time collection of detailed clinical, resource utilization, and outcome data, enhancing the reliability of our findings. Furthermore, conducting the research at the National Institute of Child Health (NICH), Karachi, the largest children's hospital in Pakistan, provides a robust overview of the disease burden in a high-volume, tertiary-care setting, offering crucial, context-specific data that has been historically lacking from the region.

Despite these strengths, the study is subject to multiple limitations. The study is a single-center design, which may limit generalizability across Pakistan, specifically the less specialized pediatric centers across Pakistan. Furthermore a more significant limitation is the lack of long-term comprehensive outcome data once shifted out of PICU for the survivors restricts our ability to

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report the functional status of these children beyond hospital discharge. While in-hospital mortality is a critical outcome, it does not capture the true burden of long-term morbidity and disability among survivors, particularly for a vulnerable group of patients with primary neurological insults. Similarly, lack of data about re-admissions hinders our ability to comment on the success of interventions in the PICU.

The results of this study help us determine the future research goals and clinical quality improvement initiatives. A multi-center study across various PICUs in Pakistan is warranted to validate these epidemiological findings and establish a national baseline for pediatric neurocritical care outcomes. In addition, future studies must focus on long-term neurodevelopmental follow-up of survivors to accurately measure the burden of morbidity associated with these conditions. Lastly, the significant association between mechanical ventilation and mortality necessitates the development and implementation of Standard Operating Procedures (SOPs) for non-invasive respiratory support and advanced airway management protocols tailored to resource-limited settings.

CONCLUSION

This prospective study from the largest pediatric intensive care unit in Sindh, Pakistan establishes that primary neurological illness constitutes a substantial proportion (25.75%) of PICU admissions and is overwhelmingly driven by Infectious/Inflammatory disorders (66.0%). The critical finding is the alarmingly high mortality rate of 47.9%, which far surpasses international standards. The requirement for mechanical ventilation was identified as a significant predictor of mortality, underscoring the severity of illness at presentation. These data affirm the urgent necessity for strengthening public health efforts to prevent CNS infections and advocate for dedicated neurocritical care training and resource allocation within PICUs across Pakistan to reduce mortality and improve both acute and long-term patient outcomes.

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