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Original Research Article

One-year neurological outcomes in critically ill children: prognostic value of the pediatric cerebral performance category score

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ABSTRACT

Background: Improved pediatric intensive care survival leaves many with long-term neurological impairments, highlighting the need for simple, reliable tools to monitor post-discharge functional outcomes. Objective of the study was to evaluate the utility of the pediatric cerebral performance category (PCPC) score in assessing neurological outcomes and predicting long-term prognosis among children admitted to the pediatric intensive care unit (PICU).
Methods: This prospective cohort study was conducted in the PICU of a tertiary care hospital and included 150 children aged 40 days to 14 years. Baseline demographic, clinical characteristics and pediatric risk of mortality (PRISM III-24) scores were recorded. Neurological outcome was assessed using the PCPC score at admission, discharge and follow-up over a period of one year. Risk factors were analyzed using multivariate logistic regression.
Results: Respiratory infection was the commonest indication for PICU admission. Neurological status deteriorated during critical illness with the proportion of children having normal neurological function decreasing from 72.0% before illness to 28.0% at discharge. Higher PRISM III-24 scores were associated with increased mortality and poorer neurological outcomes. Baseline neurological impairment, prolonged mechanical ventilation, seizures, cardiopulmonary resuscitation, central nervous system infections, and a discharge PCPC score ≥4 were significant predictors of adverse outcomes. Twelve children died during the study period. A discharge PCPC score ≥4 predicted poor neurological outcome at 12 months with a sensitivity of 75.0%, specificity of 84.9%, and AUC of 0.86 (95% CI 0.79-0.93).
Conclusions: The PCPC score is a simplest and reliable clinical tool for evaluating neurological progression and predicting long-term prognosis in critically ill children.

Keywords: PCPC score, PICU, PRISM III-24 score

INTRODUCTION

Critical illness is a leading cause of childhood morbidity and mortality worldwide. With modern advances in pediatric intensive care, survival rates are improving, but many survivors are left with persistent neurological, cognitive, and functional impairments that affect long-term quality of life. Therefore, the evaluation of outcomes beyond survival has emerged as an important component of pediatric critical care research and practice. Despite tremendous advances in survival rates in pediatric intensive care units during the last few decades, a considerable number of survivors have new or worsening functional and neurocognitive deficits. The need for standardized outcome assessment tools such as the pediatric cerebral performance category (PCPC) score is highlighted.[1]

Advances in pediatric critical care have improved survival among critically ill children; however, many survivors continue to experience long-term neurological, cognitive, and functional impairments that may adversely affect quality of life. Consequently, outcome assessment in pediatric intensive care should extend beyond mortality

alone. Standardized neurological outcome measures, such as the PCPC score, provide an objective and practical method for evaluating functional recovery, disability, and long-term healthcare needs among pediatric intensive care unit (PICU) survivors.[2]

The PCPC score is a validated global outcome measure for the evaluation of neurologic function in children after critical illness. It divides cerebral performance into six levels from normal function to brain death. The PCPC score has been widely used in pediatric intensive care research because of its simplicity, reproducibility, and ability to stratify neurological sequelae. While it does not capture subtle neurocognitive or behavioral impairments, it is a practical tool for large-scale outcome assessment in PICU survivors. The PCPC score is a commonly used standard outcome measure within pediatric critical care. The predominance of retrospective studies, reduced sensitivity to subtle neurocognitive deficits, and variability in scoring practices limit existing evidence. Moreover, its relationship with long-term functional, cognitive, and quality-of-life outcomes is not yet well established, pointing to the need for prospective studies to better assess its utility in PICU survivors.[1,2] This study prospectively evaluates the utility of the PCPC score in the assessment of neurological outcomes among children admitted to the PICU.

METHODS

This prospective observational cohort study was undertaken to evaluate neurological outcomes of critically ill children admitted to the PICU using the PCPC scale. The study was conducted at B. R. D. Medical College, Gorakhpur for over a one-year period (March 2024 to March 2025) in the pediatric department equipped with advanced facilities for the comprehensive management of critically ill children in PICUs. A total of 150 children aged between 40 days and 14 years admitted with a range of medical conditions were enrolled in this study.

Sample size calculation

The sample size was calculated using the formula for estimating a single proportion. Based on previous literature, the anticipated proportion of unfavorable neurological outcome (PCPC score 3-6) among PICU survivors was assumed to be 30%. With a 95% confidence level (Z=1.96) and an absolute precision of 7%, the minimum required sample size was calculated using the formula given, where p is the expected proportion and d is the margin of error.

$$n = Z^2 p(1-p)/d^2$$

$$N = 125$$

To account for an anticipated 15% loss to follow-up or incomplete data, the final adjusted sample size was approximately 150 children.[3,4]

The PCPC score ranges from 1 to 6, described as follows: 1-normal: normal neurological function, 2-mild disability: mild deficit, conscious and alert, 3-moderate disability: conscious with moderate deficit, 4-severe disability: severe deficit, fully dependent, 5-coma/vegetative: unresponsive, minimal brain activity, 6-brain death: no brain function, irreversible.[1]

The primary outcome was poor neurological outcome at 12 months, defined as a PCPC score ≥4. Neurological outcomes were categorized as favourable (PCPC 1-3) and unfavourable (PCPC 4-6) for prognostic analyses.

Inclusion criteria

Children aged between 40 days to 14 years admitted to the PICU for medical conditions and whose parents/guardians provided written informed consent were eligible for inclusion in the study.

Exclusion criteria

Children readmitted to the PICU during the same hospitalization period; children died within the first two hours of PICU admission and the children with incomplete clinical records or missing essential study data were excluded from the study.

Study procedure

This was a prospective observational study in the PICU of a tertiary care hospital over a defined study period. Ethical clearance was taken from institutional ethics committee. All eligible children admitted in PICU were screened for inclusion on the basis of pre-defined criteria.

Baseline demographic and clinical data were collected on admission, including age, sex, primary diagnosis, co-morbidities, and severity of illness was assessed using the pediatric risk of mortality score (PRISM III-24), calculated within the first 24 hours of PICU admission.[5] Pre-admissions neurological status was assessed using the PCPC score obtained from reports by caregivers and medical history. Relevant clinical parameters like the need for mechanical ventilation, inotropic support, duration of PICU stay, and major interventions were prospectively documented during the PICU stay. Children were followed for one year after PICU admission or until death through scheduled outpatient visits.

Neurological outcomes were assessed using the PCPC score at PICU admission, discharge, and follow-up visits. For survivors, the change in PCPC score from baseline to discharge was recorded to assess new morbidity or improvement in neurologic status. Children who died during their PICU stay were assigned a PCPC score of 6 (brain death or death according to study definition if applicable according to protocol). Variables significant in univariate analysis ($p<0.10$) were entered into a

multivariable logistic regression model. Model calibration was assessed using the Hosmer-Lemeshow goodness-of-fit test and discrimination was evaluated using receiver operating characteristic (ROC) analysis. Odds ratios with 95% confidence intervals were reported. The multivariable model demonstrated good calibration (Hosmer-Lemeshow χ^2=1.32, p=0.42) and explained a substantial proportion of outcome variability (Nagelkerke R^2=0.68). All the data were systematically entered in a structured pro forma and analyzed by SPSS v28.

RESULTS

A total of 150 children aged 40 days to 14 years were enrolled after fulfilling the eligibility criteria and were followed prospectively until PICU discharge or death. The majority were aged 1-5 years, with a slight male predominance. Most children belonged to lower socioeconomic backgrounds, and approximately one-quarter had pre-existing comorbidities, predominantly neurological disorders (Figure 1).

Respiratory infections were the most common indication for PICU admission (31.3%), followed by CNS infections (22.7%) and septic shock/sepsis (18.7%). Disease severity differed significantly across diagnostic categories. Children with septic shock/sepsis and CNS infections had significantly higher PRISM III-24 scores than those admitted with respiratory infections (Figure 2).

The requirement for intensive care interventions was greater among children who subsequently developed poor neurological outcomes. Vasopressor therapy, neuromuscular blockade, hyperosmolar therapy, and intracranial pressure monitoring were all used significantly more frequently in children with unfavorable neurological outcomes (PCPC ≥4) than in those with favorable outcomes (Figure 3).

Increasing illness severity was associated with progressive worsening of neurological outcomes. Mean discharge PCPC scores increased across PRISM III-24 severity categories, while mortality also rose from 2.4% in the mild group to 25.0% among critically ill children, demonstrating a clear association between disease severity and adverse outcomes (Table 1).

Neurological status deteriorated during PICU hospitalization. At baseline, 72.0% of children had normal neurological function (PCPC score 1), whereas only 28.0% retained normal function at PICU discharge. The proportion of children with moderate-to-severe neurological disability increased correspondingly, and 12 children (8.0%) died during hospitalization (Table 2).

Multivariable logistic regression identified several independent predictors of poor neurological outcome at 12 months. Baseline neurological impairment (PCPC ≥2) was the strongest predictor (OR 14.80; 95% CI, 5.24-41.82; p<0.001), followed by prolonged mechanical ventilation (OR 13.14; 95% CI, 4.96-34.82; p<0.001) and seizures during PICU stay (OR 12.66; 95% CI, 4.72-33.94; p<0.001). Additional significant predictors included discharge PCPC score ≥4 (OR 6.84; 95% CI, 3.12-14.98), cardiopulmonary resuscitation (OR 5.12; 95% CI, 2.18-12.04), refractory seizures (OR 4.84; 95% CI, 2.06-11.36), PRISM III-24 score >15 (OR 4.26; 95% CI, 1.98-9.16), and CNS infections (OR 2.62; 95% CI, 1.02-6.73) (all p<0.05) (Figure 4).

Long-term neurological recovery differed according to neurological status at PICU discharge. Children with favorable discharge PCPC scores (≤3) demonstrated progressive improvement during follow-up and approached normal neurological function by one year. In contrast, children with unfavorable discharge scores (≥4) continued to have persistent neurological impairment, required rehabilitation more frequently, and had lower rates of school reintegration (Table 3).

Among the 138 surviving children who completed follow-up, neurological function improved progressively after discharge. The mean PCPC score increased from 1.46 at admission to 2.48 at PICU discharge and subsequently improved to 1.46 at 12 months. Favorable neurological outcomes increased from 75.2% at PICU discharge to 96.8% at one year. Friedman repeated-measures analysis demonstrated a significant improvement in neurological status over time (χ^2=168.4, df=5, p<0.001; Kendall's W=0.27) (Table 4).

Receiver operating characteristic analysis demonstrated good predictive performance of the discharge PCPC score for poor neurological outcome at 12 months. A discharge PCPC score of ≥4 predicted unfavorable neurological recovery with an area under the curve of 0.86 (95% CI, 0.79-0.93), sensitivity of 75.0%, and specificity of 84.9% (Figure 5).

Table 1: Distribution of PRISM III-24 severity categories at PICU admission and associated mortality (n=150).

PRISM III-24 range	Severity category	Frequency (N) (%)	Mean PCPC at discharge	Mortality, N (%)
0-5	Mild	42 (28)	1.8±0.9	1 (2.4)
6-10	Moderate	58 (38.7)	2.4±1.3	3 (5.2)
11-15	Severe	32 (21.3)	3.2±1.6	4 (12.5)
16-20	Very severe	14 (9.3)	4.1±1.4	3 (21.4)
>20	Critical	4 (2.7)	5.3±0.9	1 (25.0)
Total	-	150 (100)	2.6±1.6	12 (8.0)

Table 2: Baseline (pre-illness) PCPC score of children at PICU admission and discharge (n=150).

PCPC score	Category	Baseline (N) (%)	Discharge (N) (%)	Mortality (N) (%)
1	Normal	108 (72.0)	42 (28)	0
2	Mild disability	18 (12.0)	38 (25.3)	0
3	Moderate disability	16 (10.7)	31 (20.7)	0
4	Severe disability	8 (5.3)	19 (12.7)	0
5	Vegetative state	0	8 (5.3)	0
6	Brain death	0	12 (8)	12 (100)

Mean baseline PCPC=1.49±0.89

Table 3: Correlation between PCPC at discharge and long-term outcomes.

Outcome	PCPC ≤3	PCPC ≥4	P value
Hospital discharge PCPC	1.7±0.7	4.2±0.9	<0.001*
3-month PCPC	1.6±0.6	3.4±1.2	<0.001*
6-month PCPC	1.4±0.5	2.8±1.4	<0.001*
12-month PCPC	1.3±0.4	2.4±1.6	<0.001*
Rehabilitation referral	7.2%	46.2%	<0.001*
School reintegration	86.5%	20.5%	<0.001*

*P value <0.05 (i.e. significant)

Table 4: Longitudinal trends of PCPC scores from PICU admission to 12 months (complete case analysis n=138).

Time point	Mean PCPC±SD	Median	Normal, N (%)	Favourable, N (%)	Poor, N (%)
Admission	1.46±0.84	1	102 (73.6)	130 (94.2)	8 (6.8)
PICU discharge	2.48±1.58	2	41 (30.4)	104 (75.2)	24 (24.8)
Hospital discharge	2.08±1.20	2	53 (38.4)	117 (84.8)	21 (15.2)
3 months	1.91±1.09	2	68 (49.6)	124 (89.6)	14 (10.4)
6 months	1.63±0.89	1	84 (60.8)	131 (95.2)	7 (4.8)
12 months	1.46±0.80	1	95 (68.8)	133 (96.8)	5(3.2)

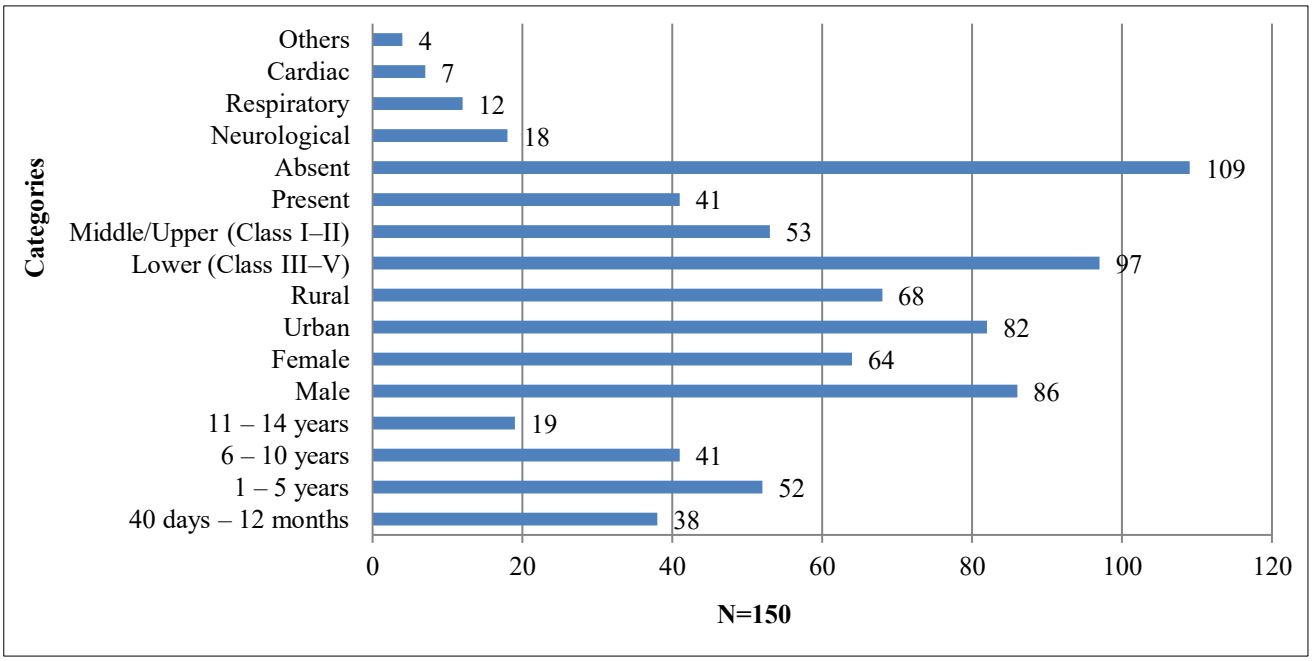

Figure 1: Baseline demographic and clinical characteristics of children admitted to the PICU.

Distribution of age groups, sex, residence, socioeconomic status, and pre-existing chronic comorbidities among children enrolled in the study. The majority of participants were aged 1-5 years, were male, belonged to lower socioeconomic strata, and had no chronic comorbidities

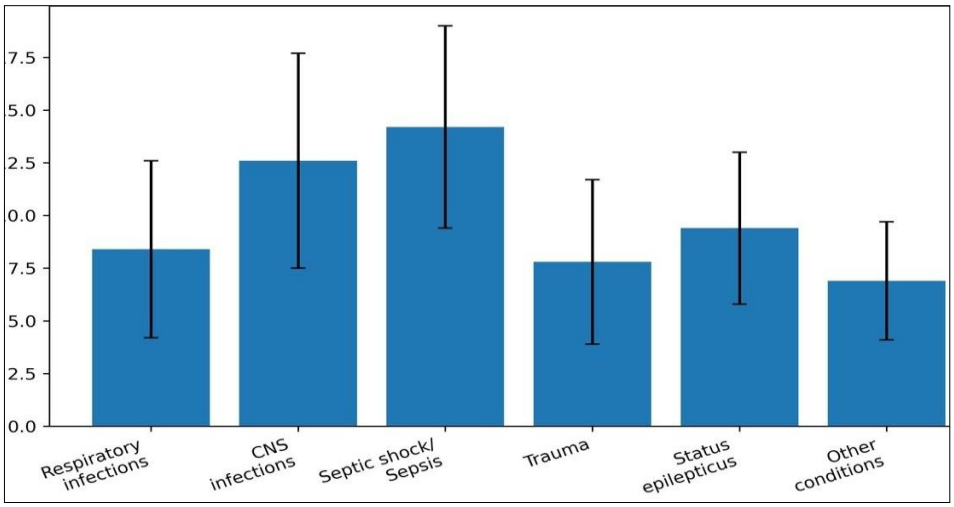

Figure 2: Diagnostic categories at PICU admission and corresponding mean PRISM III-24 scores.

Mean pediatric risk of mortality (PRISM III-24) scores according to the primary diagnosis at admission. Children admitted with septic shock/sepsis and central nervous system infections had the highest illness severity compared with other diagnostic categories

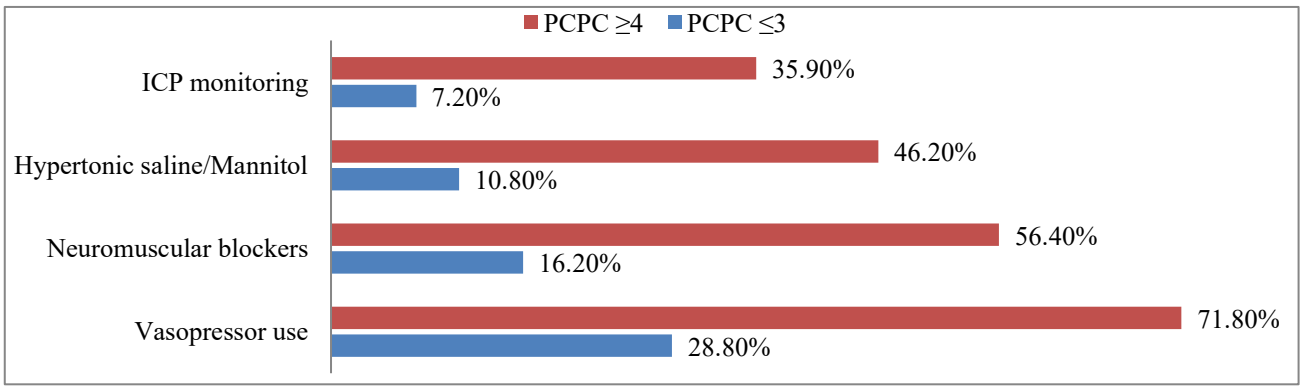

Figure 3: Association between intensive care interventions and neurological outcome at PICU discharge.

Comparison of the frequency of major PICU interventions between children with favourable neurological outcomes (PCPC ≤3) and poor neurological outcomes (PCPC ≥4). Children with poor neurological outcomes required vasopressor therapy, neuromuscular blockade, hyperosmolar therapy, and intracranial pressure monitoring more frequently

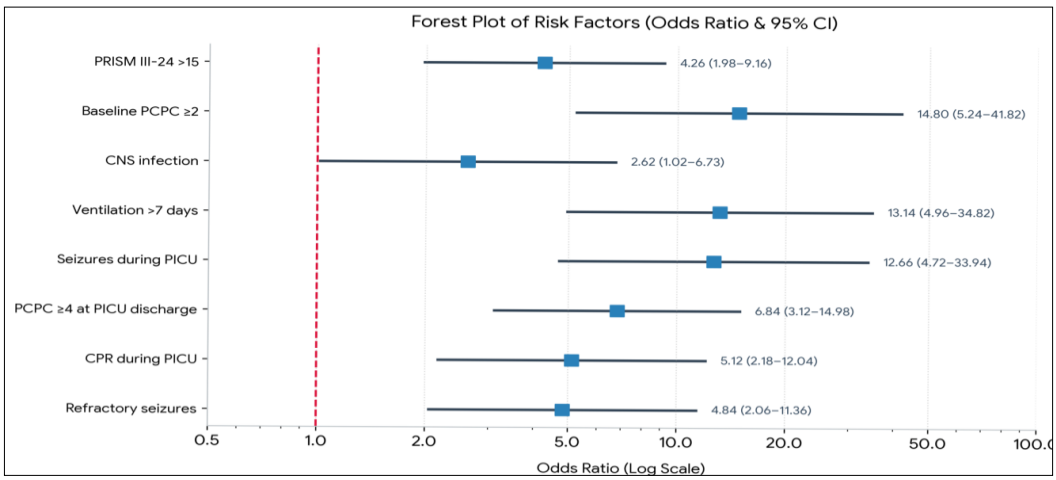

Figure 4: Independent predictors of poor neurological outcome at 12 months.

Forest plot showing adjusted odds ratios (ORs) with 95% confidence intervals from multivariable logistic regression. Baseline neurological impairment, prolonged mechanical ventilation, seizures, higher PRISM III-24 score, cardiopulmonary resuscitation, central nervous system infection, refractory seizures, and discharge PCPC score ≥4 were independently associated with poor neurological outcomes at 12 months

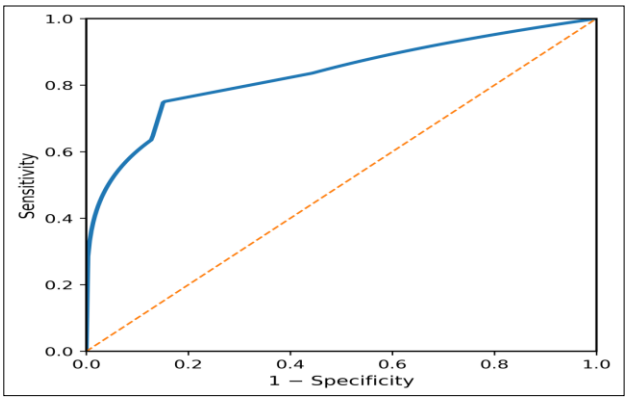

Figure 5: Receiver operating characteristic (ROC) curve of the discharge PCPC score for predicting poor neurological outcome at 12 months.

The discharge pediatric PCPC score demonstrated good discriminative ability for predicting poor neurological outcomes at 12 months, with an area under the curve (AUC) of 0.86 (95% CI, 0.79–0.93), 75.0% sensitivity, and 84.9% specificity

DISCUSSION

This prospective cohort study evaluated one-year neurological outcomes among critically ill children and examined the prognostic value of the PCPC score in predicting long-term neurological recovery. The findings demonstrate that neurological impairment remains a frequent consequence of pediatric critical illness despite improving survival rates. Although most children showed gradual neurological recovery during follow-up, those with severe neurological impairment at PICU discharge were significantly more likely to experience persistent disability after one year. These findings support the growing emphasis on functional recovery as an important outcome measure in pediatric intensive care rather than survival alone.[2,15]

The demographic profile of our cohort was comparable to that reported in previous studies, with most admissions occurring in children younger than five years and a slight predominance of males.[6-9] Younger children are particularly vulnerable to severe infections because of their developing immune system, making them more likely to require intensive care. The predominance of children from lower socioeconomic backgrounds further highlights the influence of social determinants on disease severity and access to healthcare.[10,11] Similar to earlier reports, respiratory infections were the leading cause of PICU admission, whereas children with sepsis and CNS infections presented with significantly higher PRISM III-24 scores, reflecting greater illness severity.[14-17]

A major observation of this study was the marked decline in neurological function during PICU stay. Most children had normal neurological status before the onset of critical illness; however, neurological disability increased substantially by the time of discharge. This deterioration is likely multifactorial, resulting from hypoxia, systemic inflammation, hemodynamic instability, metabolic disturbances, and direct neurological injury associated with severe illness. Comparable findings have been reported by Caprarola et al and Wilson et al, who demonstrated that neurological dysfunction commonly develops during critical illness and may persist long after hospital discharge.[15,21]

Disease severity was strongly associated with both mortality and neurological outcome. Children with higher PRISM III-24 scores had progressively worse PCPC scores and higher mortality, confirming the usefulness of PRISM III-24 as an objective measure of illness severity and prognosis.[5,14,18-20] These findings reinforce the importance of early identification of high-risk patients, allowing clinicians to anticipate neurological complications, optimize intensive care management, and initiate rehabilitation planning at an early stage.

Neurological recovery continued throughout the one-year follow-up period, although the extent of improvement differed according to neurological status at discharge. Children with favorable discharge PCPC scores demonstrated progressive improvement and achieved near-normal neurological function in most cases by 12 months. In contrast, children with severe neurological impairment at discharge showed only partial recovery and continued to have substantial functional limitations. They also required rehabilitation services more frequently and experienced poorer school reintegration, indicating that the consequences of critical illness often extend well beyond hospital discharge. Similar longitudinal recovery patterns have been reported among PICU survivors, emphasizing that neurological recovery is a gradual process requiring continued multidisciplinary follow-up and rehabilitation.[16,21-24]

Multivariable analysis identified several independent predictors of unfavorable neurological outcomes, including pre-existing neurological disability, prolonged mechanical ventilation, seizures during PICU stay, higher PRISM III-24 scores, cardiopulmonary resuscitation, and CNS infections. These factors likely reflect both the severity of the underlying illness and the extent of neurological injury sustained during critical care. Prolonged ventilation and resuscitation are frequently associated with hypoxic-ischemic injury and multiorgan dysfunction, while CNS infections and seizures can produce direct neuronal damage with lasting functional consequences. Similar risk factors have been consistently identified in previous studies evaluating neurological outcomes after pediatric critical illness.[15-17,21] Early recognition of these high-risk children may facilitate individualized rehabilitation strategies, closer neurodevelopmental surveillance, and timely family counseling.

One of the most important findings of this study was the excellent prognostic performance of the discharge PCPC score. A discharge score of ≥4 independently predicted

poor neurological outcome at one year with good discriminatory ability (AUC 0.86), supporting its value as a practical bedside prognostic tool. Unlike complex prediction models that require extensive clinical or laboratory data, the PCPC score is simple, inexpensive, and easily incorporated into routine clinical practice. These findings are consistent with the original validation of the PCPC score by Fiser et al and subsequent studies demonstrating its usefulness in assessing functional outcomes among critically ill children.[1,21] Routine assessments of PCPC scores at PICU discharge may therefore assist clinicians in identifying children who require comprehensive rehabilitation and long-term follow-up.

The strengths of this study include its prospective design, standardized neurological assessment using a validated outcome measure, and comprehensive one-year follow-up. These features allowed evaluation of both early neurological deterioration and subsequent functional recovery. However, several limitations should be acknowledged. The study was conducted at a single tertiary-care center, which may limit generalizability to other populations. In addition, although the PCPC score is a validated and practical measure of global neurological function, it does not capture subtle cognitive, behavioral, or psychosocial impairments that may become apparent later in childhood.[1,2] Future multicenter studies incorporating detailed neuropsychological assessment may provide a more comprehensive evaluation of long-term outcomes.

Overall, our findings demonstrate that neurological impairment remains an important consequence of pediatric critical illness despite improving survival. The discharge PCPC score provides a simple, reliable, and clinically meaningful method for identifying children at risk of persistent neurological disability. Incorporating standardized neurological assessment into routine PICU practice may facilitate early intervention, optimize rehabilitation planning, and improve long-term functional outcomes among survivors of critical illness.[1,2,15,21]

Limitations

Despite its strengths, the present study has certain limitations. Being a single-center study, the findings may have limited generalizability to other populations with different demographic or clinical profiles. The PCPC score, while practical and widely used, provides a broad measure of neurological function and may not detect subtle cognitive, behavioural, or educational impairments that can occur following critical illness. The potential confounding factors such as pre-existing developmental delays, nutritional status, and post-discharge rehabilitation interventions may have influenced outcomes but were not fully controlled. Finally, the observational design of the study limits the ability to establish causality between identified risk factors and neurological outcomes.

CONCLUSION

The PCPC score is a simple, practical, and reliable tool for assessing neurological outcomes in critically ill children. A discharge PCPC score ≥4 was strongly associated with poor neurological outcomes at 12 months, highlighting its value as an early prognostic indicator. Routine neurological assessment using the PCPC score may facilitate timely identification of high-risk children, guide rehabilitation planning, and support long-term follow-up strategies aimed at optimizing neurological recovery and functional outcomes among PICU survivors.

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