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Efficiency of PICU using Functional Status Scale (FSS): A Pilot Study

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Declaration
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Dr. Summan Sohail Khan (Clinical Fellow PCCM): Literature review, Initial draft, data collection, manuscript writing
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ABSTRACT

Background: Several clinical predictors model have been reported for the outcome of acute critically ill children from Pediatric Intensive care units (PICUs) globally. Limited data is available on functional state of children at discharge from PICU. **Objective:** To assess the efficiency of a PICU by evaluating functional recovery in children from admission to discharge using the Functional Status Scale (FSS). **Study design:** This is a descriptive, observational study. Setting: This study was conducted in the PICU of Children's Hospital Korangi, Karachi, Pakistan. **Duration of study:** Four-month period (From December 5th, 2023, to March 30th, 2024). **Methods:** A total of 225 patients were enrolled. Patients admitted for more than 24 hours and discharged alive were retrospectively reviewed. FSS scores were recorded within the first 24 hours of admission and again at discharge from PICU. Patients were categorized into two groups: Group A (FSS ≤9) and Group B (FSS >10). Demographic and clinical variables, including age, gender, primary diagnosis, mechanical ventilation, vasoactive support, length of stay, and Pediatric Risk of Mortality (PRISM III) scores, were analyzed. **Results:** The median (IQR) age of participants was 10 months (4-24 months); 69.3% of under 2 years of age, with a male predominance of 60%. Respiratory diseases were the leading cause of admission, 86.6%, followed by neurological conditions. The median PRISM-III scores and median FSS score were 28 (21-29.8) and 22 (18-27) at admission, respectively. The median of total score declined markedly from 23 (IQR 18–27) at admission to 8 (IQR 7–9) at discharge. 84.4%(n=190) of patients achieved FSS near-normal, and 46% (n=104) were 6 (normal health) at discharge. Only 15.6% (n=35) had moderate to severe impairments in functional state at discharge. **Conclusion:** Nearly 85% of acute critically-ill children regained the normal functional and health state at discharge from PICU in this study. Further larger studies are needed to validate our results.

INTRODUCTION

The Pediatric Intensive Care Unit (PICU) is an allocated geographical area of a hospital which specifically designed for comprehensive care and monitoring of children with shock, acute respiratory failure, or other potentially life-threatening conditions. The outcome of PICUs of high-income countries is very well established; a recent study reported a 1.8% mortality rate, and approximately 4.8% of survivors have functional disabilities at discharge. [1,2]

There is a traditional view that there is no need for PICUs in low- and middle-income countries for various possible reasons like high cost, lack of infrastructure, non-availability of trained healthcare providers, and high need for primary care facilities. However, the burden of children with acute critical illness like shock, respiratory failure, and acute neurological illnesses in a previously healthy children is significantly high and increasing in LMICs.[2] The parents and primary care physicians have a desire to save the lives of acutely ill children from potentially reversible illness. The mortality rate of children under five years of age is still high (58 per 1000 live births) in Pakistan, [3] which is a key indicator of child health. The COVID-19 pandemic brought changes to the intensive care services in the public, policymakers, and healthcare organizations globally. There is a great need for basic pediatric intensive care services in LMICs to save the lives of acute life-threatening critically ill children. [4] The improvement in the mortality rate of children under five (<25/1000 live births) is one of the goals of SDG 3.2.1. [3] Within this framework, pediatric intensive care units (PICUs) are critical in ensuring that critically ill children not only survive but also return to functional health, a dimension often overlooked in low- and middle-income countries. We defined "Efficiency of PICUs" as the recovery of children to normal health (pre-illness state) after acute illness at discharge from PICU.

Prediction of outcomes of PICU is pivotal. Multiple prediction models and clinical scoring system have been validated in PICUs worldwide. [5,6] Functional Status Scale (FSS), developed by Pollack et al. under the Collaborative

Pediatric Critical Care Research Network (CPCCRN), is a pure bedside, physiology-based, high inter-rater reliability, age-independent clinical parameter to evaluate incidence of morbidity in critically-ill children at discharge from PICU. [7–9]

The objective of this study is to assess the efficiency of PICU using the change in FSS from admission to discharge of critically-ill children from PICU (ΔFSS= FSSa – FSSd).

MATERIALS & METHODS

Study Design & Duration: This descriptive observational study was conducted over 4 months from December 5, 2023, to March 30, 2024.

Study Setting: In the PICU of Children's Hospital Korangi, under the governance of Sindh Institute of Child Health & Neonatology (SICHN). SICHN is an organization of acute care neonatal and pediatric patients under the Government of Sindh. PICU is a closed multidisciplinary, 28-bed, follows the 4-S framework of ICU. [10] This institution is accredited for the Pediatric Critical Care Medicine (PCCM) fellowship.

Participants: Non-eligible cases included those referred to other facilities, discharged against medical advice, expired, or with incomplete or missing FSS data.

Study sample size: The sample size was not calculated due to its exploratory nature.

Instrument used to assess the Functional State: This scale assesses the functional status based on physiological parameters of critically ill children. [9] It evaluates six critical domains: mental status, sensory function, communication, motor skills, feeding, and respiratory status. [Annexure attached]. The score of each domain may range from 1 to 5, where 1 represents the best functional status in each of the domains and 5, the worst functional status. We dichotomized the FSS score on discharge into two groups: Group A [High Efficiency] included children with a FSS score of 6-9, and Group B [Low Efficiency] included children with a FSS score of 10-30. PRISM-3 is a very well-established, validated clinical tool used for the incidence of morbidity in the PICUs. [8]

Outcomes

The improvement in the functional state of acute critically-ill children were assessed quantitatively (total and domain-specific score) by comparing and calculating the difference in FSS score at admission (FSSa) and on discharge (FSSd) PICU day. We dichotomized in study participants into two groups based on FSS at discharge from PICU: children with high function group (Group 1; FSS <9) and low function group (Group 2; FSS > 10).

Data Collection & Data Analysis: Data were collected by a PICU fellow using a structured questionnaire designed on REDCap. The information gathered included demographic variables (age, gender, admitting diagnosis, and comorbidities PRISM-3 on admission), clinical indicators (use of respiratory support including non-invasive & invasive ventilation, vasoactive support, cardiopulmonary resuscitation status, total duration of intubation, and PICU length of stay). FSS of each domain and the total score were recorded at admission and on the discharge day of the PICU. Statistical analysis was performed using SPSS version 23. Categorical variables were evaluated using Chi-square or Fisher's exact test, and continuous variables such as PRISM III scores and FSS scores were compared using the Mann–Whitney U test. A p-value <0.05 was considered statistically significant.

RESULTS

225 patients were recruited for the study. The median (IQR) age of participants was 10 mos. (4-24 mos.); majority of these patients (69.3%) were under the age of two, and 60% were male. Patients' characteristics are shown in Table 1. Respiratory illnesses were the leading cause of admission, particularly in younger children (Group 1: 88.4% *vs.* Group 2: 74.3%, (p < 0.002). The median (IQR) FSS score on admission was 22 (18-27) and the median (IQR) PRISM-III score was 28 (21-29.8) at admission in PICU. Both scores were demonstrating the high acuity of critical illnesses (p<0.001). The median (IQR) FSS was 8 (7-9) at discharge from PICU. More than two-thirds of children (84.4%; n=190) were normal and near normal in health status (Group 1: FSS <9) at discharge from PICU. Only 15.6% (n=35) of children were categorized in Group 2, who had some functional disabilities at discharge. Nearly half of the cohort (46%; n = 104) regained an FSS score of 6 at discharge, indicating a full return to their pre-illness functional baseline. However, the severe dysfunction (FSS> 20) was observed in 5% (n=11) of children at discharge from PICU. Acute neurological illnesses were significantly associated with worse outcomes (Group 1: 15.3% *vs.* Group 2: 40%), p < 0.002). PICU interventions (like MV and VAD), age, gender, and length of stay were not statistically significant between the two *groups* at discharge. (Table 1)

Table 1

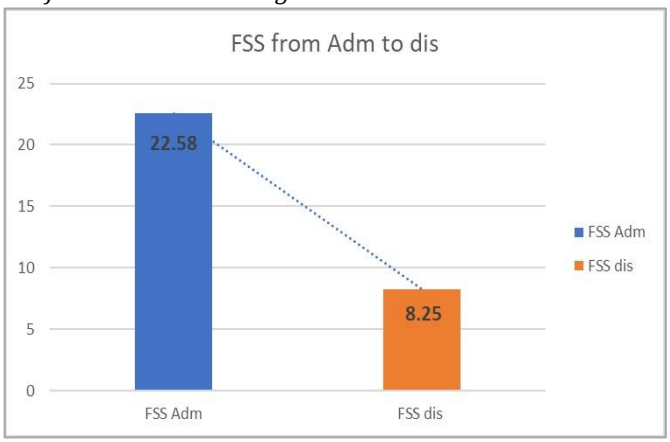
Patients' characteristics (n=225)

Variable	Total (n=225)	Group A (FSS <9)	Group B (FSS >10)	P - Value
Gender				
Male	135(60)	115(60.5)	20(57.1)	0.707
Age Cat				
<2 year	156(69.3)	132(69.5)	24(68.6)	0.915
> 2 years	69(30.7)	58(30.5)	11(31.4)	
Admitting Diagnosis				
Respiratory	136	110(88.4)	26(74.3)	<0.002
CVS	15	11(11.6)	4(14.3)	
CNS	33	23(15.3)	10(40)	
Renal	5	3(3.2)	2(8.6)	
Others	36	30(40.5)	6(37.1)	
PICU intervention				
Mechanical Ventilation	142(63.1)	117(61.6)	25(71.4)	0.267
Ionotropic Support	186(82.7)	156(82.1)	30(85.7)	0.604
LOS Cat				
<=4	148(65.8)	124(65.3)	24(68.6)	0.705
>4	77(34.2)	66(34.7)	11(31.4)	

Functional recovery was striking both in the overall and domain-specific aspects of the Functional Status Scale (FSS). The total score declined markedly from a median of 23 (IQR 18–27) at admission to 8 (IQR 7–9) at discharge (p < 0.001) (Fig. 1).

Figure 1

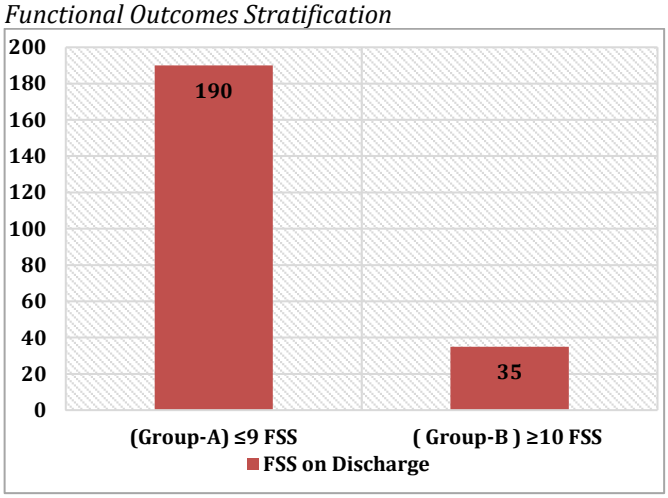
FSS from Adm to Discharge



Domain-specific analysis demonstrated statistically significant improvements across all six areas ($p < 0.001$ for each). The largest functional recovery was observed in feeding (mean ΔFSS 3.1) and mental status (mean ΔFSS 2.7), followed by motor function (2.4), sensory (2.5), respiratory (2.1), and communication (1.9) (Fig. 2).

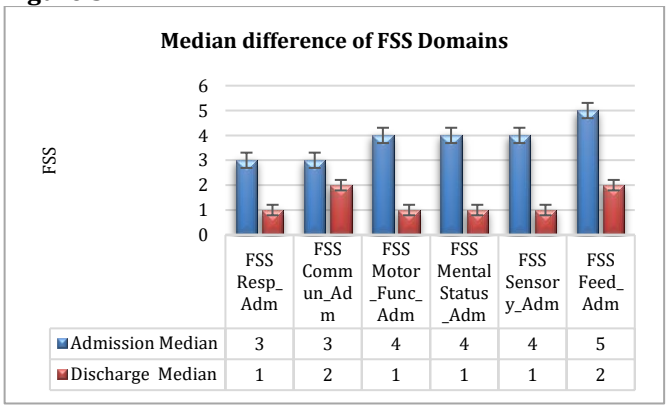
Figure 2

Functional Outcomes Stratification



The overall improvement from admission to discharge was also reflected in a mean ΔFSS of 14 ± 5.3, signifying a substantial gain in functional status during the PICU stay. Delta FSS was stratified into two groups: children with a ΔFSS >10, reflecting marked functional recovery (78%, n=177), and those with a ΔFSS ≤9, indicating comparatively limited improvement (21%, n=48).

Figure 3



DISCUSSION

The majority of critically ill children in the PICU showed significant improvement in functional status on discharge, with 84% achieving a normal or near-normal state (FSS ≤9), underscoring the efficiency of intensive care. PICUs play a vital role in restoring function and improving long-term child health. A greater positive ΔFSS reflected meaningful recovery, while smaller changes identified children at risk for persistent morbidity. [11]

In pediatric critical care, a meaningful outcome extends beyond mortality and morbidity reduction to functional recovery and quality of life. Traditionally, in the past, different severity scores were used, such as PRISM-III and p-SOFA, and remain valuable for predicting mortality; they do not reflect morbidity or long-term outcomes. [12] Pollack et al. addressed this gap with the development of the Functional Status Scale (FSS) in 2009, allowing morbidity to be quantified alongside survival. However, evidence from LMICs remains sparse, with studies in Pakistan reporting morbidity rates of 15-20%. (13–15)

Consistent with global and regional evidence, our study observed a male predominance among PICU admissions (60%). Similar distributions have been reported in a cohort, showing this trend is not confined to resource-limited settings. [2,6] While males are admitted more frequently, evidence suggests females may demonstrate relative protection in critical illness, likely mediated by hormonal and immunological factors. [13]

Age has traditionally been associated with vulnerability to critical illness, particularly in infants and young children. The majority (69.3%) of our study population was < 2 years old, although age did not significantly influence functional outcomes at discharge. This finding contrasts with international data, such as that from (Ong et al.,2016), who reported that younger pediatric patients often experience poorer functional recovery due to developmental immaturity and limited physiological reserve. [6] However, studies conducted in local contexts, including that by (Sakina et al.,2024), suggest that comprehensive supportive strategies such as timely nutritional rehabilitation and continuous caregiver presence may mitigate these risks and enhance recovery, particularly in infants. [14] These factors may account for the absence of age-related disparities in functional improvement observed in our cohort. This underscores the importance of context-specific clinical practices and family-centered care models in influencing PICU outcomes across different pediatric age groups.

A disease-specific analysis revealed that respiratory illnesses were the predominant reason for PICU admission, accounting for 86% of cases, particularly among those who achieved favorable functional outcomes at discharge. This aligns with trends reported in South Asian and global PICU populations, where respiratory infections remain the leading cause of critical care admission due to high disease burden and limited access to preventive care. [14,15] In contrast, children admitted with central nervous system (CNS) pathologies exhibited significantly worse functional outcomes. This disparity underscores the unique vulnerability of the developing brain to both primary neurologic insults and secondary

systemic complications such as hypoxia, inflammation, and metabolic dysregulation. [16,17]

Similar findings have been documented, reporting that pediatric patients with neurological diagnoses had significantly higher rates of long-term disability post-PICU discharge, compared to those with respiratory or infectious etiologies. [6] Complementing this, another study demonstrated that neurological injury in children is independently associated with adverse neurocognitive and physical outcomes due to both direct brain injury and sequelae of systemic inflammation. [16]

To assess such outcomes comprehensively, several tools are now available. The Functional Status Scale (FSS) remains a practical, bedside-oriented measure that offers reliable domain-specific insight into physical and neurological function. However, broader multidimensional tools like the Pediatric Quality of Life Inventory (PedsQL) and PICS-p checklists capture additional domains, including psychosocial health, school re-entry, and family functioning. [18,19] While FSS is highly sensitive to changes in basic physical functions, instruments like PedsQL offer complementary value in long-term quality of life assessments, and PICS-p tools are particularly useful in tracking cognitive, emotional, and social outcomes in post-ICU pediatric populations. [20]

These comparisons underscore the diagnostic heterogeneity of pediatric critical illness and the importance of using a combination of functional and quality-of-life measures for accurate prognostication and tailored follow-up, especially for children with neurologic involvement.

While advancements in neurocritical care have improved survival, our findings reinforce that CNS pathologies continue to pose a substantial risk for functional morbidity, highlighting the need for early neurorehabilitation and structured long-term follow-up. These comparisons emphasize the diagnostic heterogeneity of pediatric critical illness and the importance of etiology-specific prognostication in functional outcome studies like ours.

The significant correlation observed in our study between PRISM III scores and Functional Status Scale (FSS) at admission highlights the complementary role of physiological and functional assessments in critically ill children. Higher PRISM scores were strongly associated with greater functional impairment, underscoring that early physiological derangement often mirrors the extent of organ dysfunction and neurodevelopmental compromise. [8]

This aligns with findings from the PARDIE study, which reported that physiological instability at admission correlates with increased risk of morbidity. [9] with the results of the Functional Status Scale validation study by (Pollack et al.,1996) which demonstrated that PRISM III scores closely correlate with FSS ratings, particularly in predicting poor short-term functional outcomes. [7]

Similarly, a prospective cohort study by (Ong et al.,2016) evaluating pediatric critical care survivors found that higher illness severity at admission was significantly associated with persistent deficits in mobility, feeding, and cognitive domains at discharge, even in children who survived hospitalization. [6] These international findings reinforce the predictive strength of PRISM not only for mortality but also as a practical marker of morbidity. When used alongside FSS, it allows for early identification of high-risk patients and facilitates goal-directed rehabilitation planning to support a return to normal function.

A central feature of our analysis was the use of FSS, defined as the difference between the worst functional status at admission and the status at discharge. The mean Delta FSS of more than 10 reflects a marked degree of recovery in most patients. As a single numeric indicator, Delta FSS (ΔFSS) captures the magnitude of change in a patient's condition throughout critical care, making it a valuable measure of PICU efficiency. [21] This metric not only reflects therapeutic effectiveness but may also serve as a benchmark for functional outcomes across institutions, particularly in resource-limited settings where survival alone is not an adequate indicator of quality care. [21]

Our findings diverge from several international studies that have shown a strong association between prolonged mechanical ventilation and poorer functional outcomes in critically ill children. (Odetola et al.,2009) found that extended ventilatory support correlated with increased morbidity and longer rehabilitation needs in pediatric patients. [22] Similarly (Ong et al. 2016) demonstrated that longer durations of mechanical ventilation significantly predicted post-discharge disability, particularly affecting motor and feeding functions. [6] A recent prospective multicenter study from South America further supports this relationship, reporting that although PICU survival was high (90.9%), acquired morbidity at discharge (26.9%) exceeded mortality. [23] Functional status declined in 42% of survivors, with motor and feeding domains most frequently impaired, especially among those with prolonged invasive ventilation and extended hospitalization. [23]

These contrasting findings highlight the importance of contextual factors in shaping functional outcomes and underscore the need for multicenter research within Pakistan to determine whether such practices consistently mitigate morbidity. Furthermore, the higher incidence of morbidity relative to mortality across global studies calls for broader adoption of functional outcome measures such as the Functional Status Scale to more accurately evaluate PICU effectiveness.

Length of stay (LOS) in the PICU is often used as a surrogate marker of disease severity and post-illness recovery trajectory. In our study, a majority of patients (66%) had a PICU stay of four days or less, with no statistically significant association found between LOS and functional outcomes at discharge, as measured by the Functional Status Scale (FSS). This finding contrasts with international literature, such as the review by (Hiser et al.,2023), which reports that prolonged ICU admission is a key risk factor for post-intensive care syndrome in children and is frequently associated with long-term physical, cognitive, and psychosocial impairments. [20]

The domain-specific improvements in FSS scores are particularly noteworthy. Median feeding scores improved from 5 to 2, motor function from 4 to 1, and respiratory function from 3 to 1. Similar results were observed by

(Namachivayam et al., 2010) who reported that functional recovery in physical domains is most robust during the early critical care phase. Improvements in sensory, communication, and mental status domains, though significant, were less marked. [1] This supports the concept of post-intensive care syndrome in pediatrics (PICS-p), wherein cognitive and emotional domains recover more slowly. [20]

The Functional Status Scale (FSS) is a practical tool for assessing the physical condition of children both in the PICU and on general wards. It is objective, does not rely on subjective judgment, and does not require specialized equipment. [24] Like the FSS-ICU, it can be easily integrated into routine clinical care. Owing to its simplicity and ease of interpretation, the pediatric FSS can also be readily used by physical therapists and other healthcare providers in daily practice. The Functional Status Scale, validated across diverse settings, has proven to be a reliable and practical tool for routine functional assessments in critically ill children. [24]

The strength of this study is the first kind of study reporting improvement in functional state in acute critically-ill children on discharge as compared to it at admission using FSS.

Despite these strengths, this study has several limitations. Being a single-center, retrospective, and small sample size, generalizability is limited. Functional outcomes were only measured at discharge; there were no follow-ups in our cohort. Additionally, factors such as socioeconomic status, parental education, and home support systems, which are known to affect rehabilitation, were not evaluated. Finally, while FSS is robust for physical and cognitive domains, it does not assess psychosocial aspects, which are increasingly recognized as key outcomes.

CONCLUSION

Defining PICU efficiency as survival with restored function aligns with Sustainable Development Goal 3, making intensive care an essential pillar of child health. Through the 4S model (Space, Staff, Stuff, and Systems), PICUs deliver both lifesaving and life-restoring care. In our study, most critically ill children demonstrated significant functional recovery on discharge using the FSS, underscoring the value of PICU care in resource-limited settings

DECLARATIONS

Data Availability Statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate

Study approved ethical clearance from the Institutional Review Board obtained number(IRB ID# SICHN/EX-008/20225)

Informed consent was waived due to retrospective data.

Consent for publication

Approved by the IRB committee

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