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Original Research Article

Paediatric Sequential Organ Failure Assessment (p-SOFA): A New Mortality Prediction Score in Children Aged 1 Month to 18 Years Admitted with Sepsis in Paediatric Intensive Care Unit

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Conflict of interest: Nil

Abstract

Background: Sepsis remains an important cause of mortality in children admitted to paediatric intensive care units. The paediatric Sequential Organ Failure Assessment (p-SOFA) score provides an organ dysfunction-based method of assessing illness severity, but the prognostic value of serial p-SOFA assessment in the first 72 hours requires further evaluation.

Objective: To evaluate admission p-SOFA, 72-hour p-SOFA and Delta p-SOFA for mortality prediction in children aged 1 month to 18 years admitted with sepsis to a Paediatric Intensive Care Unit.

Methods: This prospective observational study included 58 children with sepsis admitted to the Paediatric Intensive Care Unit of a tertiary-care hospital over 18 months. p-SOFA was calculated at admission (T0) and at 72 hours (T72). Delta p-SOFA was calculated as T0 minus T72; positive values indicated improvement. The primary outcome was mortality. Receiver operating characteristic analysis was performed to assess discrimination and identify optimal cut-offs.

Results: Of 58 children, 40 recovered and 18 died which gave a mortality rate of 31.03%. Non-survivors had greater metabolic and haemodynamic derangement at admission. Median admission p-SOFA was higher in deaths than in recovered children (11.0 vs 8.0; $p<0.001$). At 72 hours, the separation was more marked (18.0 vs 4.0; $p<0.001$). Median Delta p-SOFA was negative in deaths and positive in recovered children (-6.0 vs 4.0; $p<0.001$). Admission p-SOFA had an AUC of 0.899; a cut-off of >=10 had 88.9% sensitivity and 75.0% specificity. The 72-hour p-SOFA had AUC 1.000 at cut-off >=10 and Delta p-SOFA had AUC 0.993 at cut-off <=0.

Conclusion: Admission p-SOFA is useful for early risk stratification in paediatric sepsis, but sequential assessment at 72 hours and Delta p-SOFA provide stronger prognostic information by capturing the trajectory of organ dysfunction.

Keywords: Child; Sepsis; Paediatric Intensive Care Unit; Sequential Organ Failure Assessment; Organ Dysfunction; Mortality; Prognosis.

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Introduction

Sepsis is a major cause of childhood morbidity and mortality and continues to place a substantial burden on intensive care services worldwide. Global analyses have shown that sepsis contributes substantially to mortality, while paediatric and neonatal sepsis reviews emphasize the disproportionate burden in children, particularly in low- and middle-income settings [1,2]. International PICU data have also demonstrated wide variation in outcome, reflecting differences in age, case mix, pathogen profile, comorbidity, timeliness of recognition and access to organ support [3]. Paediatric sepsis has traditionally been defined using infection, systemic inflammation and organ dysfunction criteria, and the 2005 International Pediatric Sepsis Consensus Conference provided a widely used framework for paediatric sepsis and organ dysfunction [4]. More recent sepsis concepts shifted attention from inflammation alone to life-threatening organ

dysfunction caused by a dysregulated host response [5,6]. Contemporary paediatric consensus work has further reinforced this organ dysfunction-centred approach through Phoenix sepsis criteria and score development [7,8]. These developments support the clinical need for structured bedside tools that quantify organ dysfunction rather than relying only on subjective clinical impression and align with guideline emphasis on early recognition and organ-support escalation [9].

The Sequential Organ Failure Assessment score was originally designed to describe the severity and evolution of organ dysfunction in critically ill adults [10].

Its serial use is important because sepsis is dynamic: improvement or worsening over the first 48 to 72 hours may be more informative than a single score at admission [11].

Matics and Sanchez-Pinto adapted SOFA to paediatric physiology by using age-adjusted thresholds and paediatric-specific parameters, allowing the p-SOFA score to be applied across childhood [12].

Subsequent paediatric studies and meta-analytic evidence suggest that age-adapted SOFA/p-SOFA performs well for mortality prediction in suspected infection and sepsis [13,14].

Several paediatric organ dysfunction frameworks exist, including PELOD-2 and the broader PODIUM criteria, and they have strengthened the view that organ dysfunction should be measured systematically in critically ill children [15-19].

However, many practical questions remain in single-centre PICU settings: what admission p-SOFA cut-off best identifies mortality risk, whether 72-hour p-SOFA improves prediction, and whether Delta p-SOFA can act as a simple marker of treatment response.

This study therefore evaluated admission p-SOFA, 72-hour p-SOFA and Delta p-SOFA as predictors of mortality in children aged 1 month to 18 years admitted with sepsis to a tertiary-care PICU.

Methods

Study design and setting: This was a prospective observational study conducted in the Paediatric Intensive Care Unit, Department of Paediatrics, Geetanjali Medical College and Hospital, Udaipur, Rajasthan.

The study was conducted over 18 months after approval from the Institutional Ethics Committee.

Study Population: The study population included children aged 1 month to 18 years admitted to the PICU with sepsis. Sepsis was diagnosed according to paediatric sepsis criteria based on suspected or proven infection with systemic inflammatory response and organ dysfunction, in line with the paediatric consensus framework [4].

Eligibility Criteria: Children aged 1 month to 18 years admitted to PICU with sepsis and whose parents or guardians provided written informed consent were included. Children were excluded if PICU stay was less than 72 hours, if consent was not provided, or if they had chronic liver disease, chronic renal disease, congenital heart disease, pre-existing haematological disorder or inborn error of metabolism.

Sample Size: The minimum required sample size was calculated as 58 using the formula N=(Z1-alpha/2 + Z1-beta)^2 x P x (1-P)/E^2, with 95% confidence level, 80% power, paediatric sepsis prevalence of 8-10% and an absolute error of 10%. The final analysed cohort included 58 children.

Data Collection: Demographic details, clinical features, duration of PICU stay, need for inotrope support, need for mechanical ventilation and final outcome were recorded using a predefined proforma. Clinical and laboratory variables relevant to p-SOFA scoring and outcome analysis were recorded at admission and at 72 hours.

p-SOFA Assessment: The p-SOFA score was calculated at admission (T0) and at 72 hours (T72) using the six organ-system domains of respiratory, coagulation, hepatic, cardiovascular, neurological and renal dysfunction, as described in the paediatric adaptation of SOFA [12]. Delta p-SOFA was calculated as p-SOFA at T0 minus p-SOFA at T72. Therefore, a positive Delta p-SOFA indicated improvement in organ dysfunction, while a value of zero or less indicated no improvement or worsening.

Outcome Measure: The primary outcome was mortality during the hospital/PICU course. Children who survived and were discharged or recovered were analysed as the recovered group; children who died formed the mortality group.

Statistical analysis: Data were analysed using descriptive and inferential statistics. Categorical variables were expressed as number and percentage.

Continuous variables were expressed as mean +/- standard deviation or median with interquartile range, as appropriate. Outcome groups were compared using Fisher's exact test for categorical variables and the Mann-Whitney U test for continuous variables. Receiver operating characteristic curves were used to evaluate admission p-SOFA, 72-hour p-SOFA and Delta p-SOFA for mortality prediction. The area under the curve, 95% confidence interval, optimal cut-off, sensitivity, specificity, positive predictive value,

negative predictive value and accuracy were calculated. A p value <0.05 was considered statistically significant.

Results

A total of 58 children with sepsis were included in the final analysis. Forty children recovered and 18 died, giving a mortality rate of 31.03%.

The study flow and serial p-SOFA assessment pathway are shown in Figure 1.

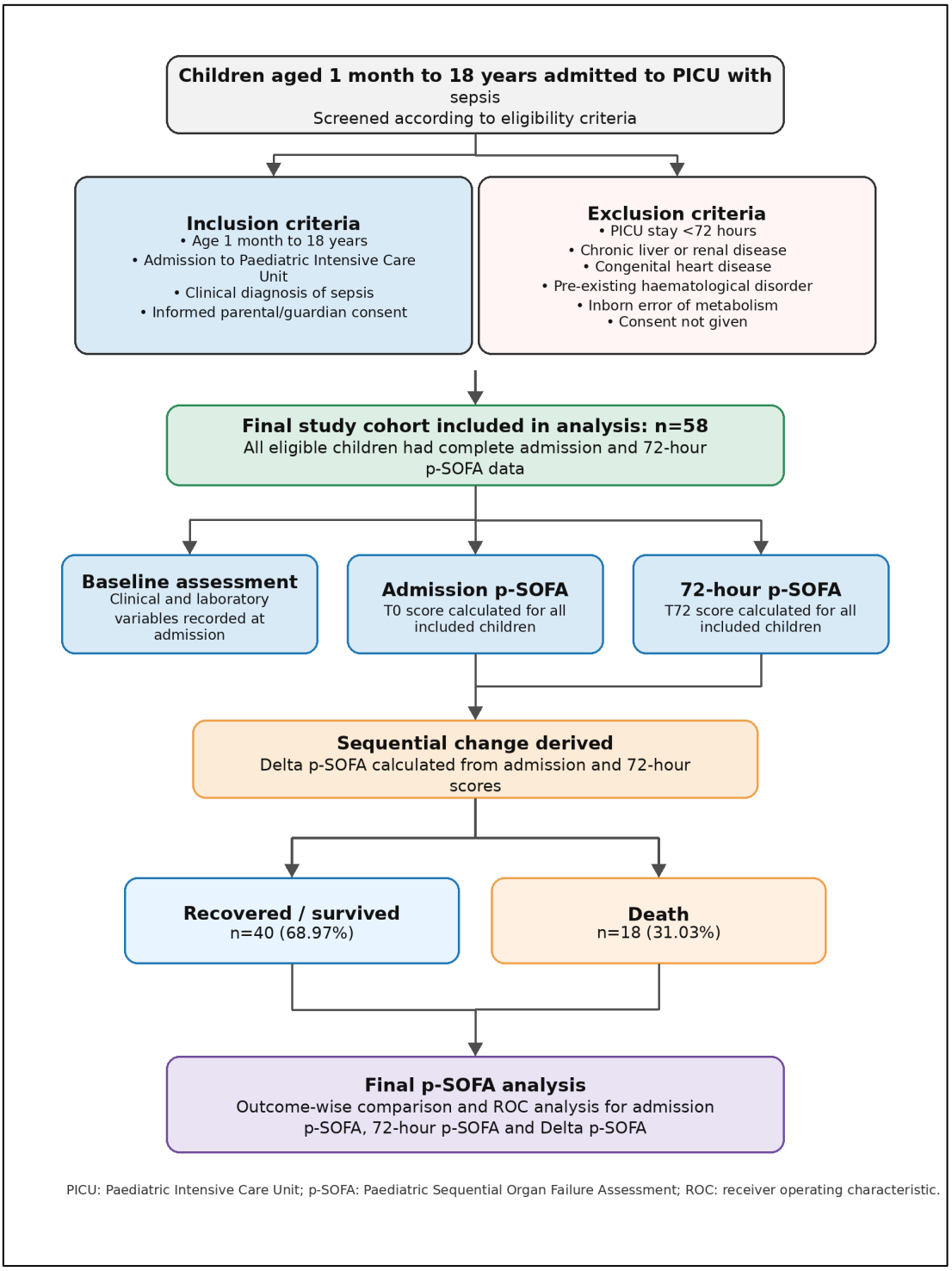


Figure 1: Study flowchart showing enrolment, serial p-SOFA assessment and clinical outcomes.

Baseline Characteristics by Outcome: Baseline demographic, clinical and laboratory characteristics are summarized in Table 1. Age and sex distribution were similar between groups. Children who died had significantly greater inotrope requirement at admission, lower oxygen saturation, lower MAP, lower GCS, lower platelet count, lower pH, lower bicarbonate and higher serum lactate.

These differences indicate greater haemodynamic and metabolic derangement among non-survivors at presentation.

Table 1: Baseline demographic, clinical and laboratory characteristics by outcome.

Variable	Recovered (n=40)	Death (n=18)	p value
Age (months)	37.40 ± 43.14	27.56 ± 22.80	0.866
Male sex	23 (57.5)	12 (66.7)	0.573
PICU length of stay (days)	5.72 ± 4.99	6.00 ± 4.19	0.517
Mechanical ventilation	33 (82.5)	18 (100.0)	0.087
Inotrope requirement at T0	14 (35.0)	15 (83.3)	0.001
SpO2 at T0 (%)	90.55 ± 5.86	85.28 ± 9.82	0.027
MAP at T0 (mmHg)	53.65 ± 9.52	47.28 ± 4.92	0.016
GCS at T0	12.82 ± 2.85	10.72 ± 3.95	0.034
Platelet count T0 (×10³/µL)	129.40 ± 83.98	87.56 ± 76.47	0.020
Serum bilirubin T0 (mg/dL)	2.27 ± 3.41	2.67 ± 2.70	0.285
Serum creatinine T0 (mg/dL)	1.35 ± 0.89	1.38 ± 0.94	0.827
ABG pH	7.34 ± 0.08	7.25 ± 0.11	<0.001
HCO3 (mEq/L)	19.91 ± 3.88	14.11 ± 4.37	<0.001
Serum lactate (mmol/L)	2.27 ± 1.16	8.09 ± 4.09	<0.001

Values are mean +/- SD or n (%). P values were calculated using Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables.

PICU: Paediatric Intensive Care Unit; MAP: mean arterial pressure; GCS: Glasgow Coma Scale.

p-SOFA-related organ dysfunction parameters at 72 hours: The organ variables used for p-SOFA assessment were compared at 72 hours between recovered children and deaths as shown in Table 2. Children who died had worse respiratory, coagulation, hepatic, cardiovascular, neurological and renal dysfunction at this time point. The differences were seen in oxygenation, platelet count, serum bilirubin, MAP, inotrope dose, GCS and serum creatinine.

Table 2: p-SOFA-related organ dysfunction parameters at 72 hours by outcome.

p-SOFA domain	T72 parameter	Recovered, n=40 Median (IQR)	Death, n=18 Median (IQR)	Exact p-value	Recommended reporting
Respiratory	SpO_2 T72 (%)	95.0 (92.0–98.0)	82.0 (65.8–87.8)	0.000000012	<0.001
	PaO_2 T72 (mmHg)	98.0 (89.0–131.5)	52.5 (30.2–84.8)	0.000007018	<0.001
Coagulation	Platelet count T72 (×10³/µL)	206.0 (117.5–328.0)	36.0 (17.0–117.0)	0.000118518	<0.001
Hepatic	Serum bilirubin T72 (mg/dL)	1.20 (0.80–1.62)	9.55 (3.80–13.22)	0.000013728	<0.001
Cardiovascular	MAP T72 (mmHg)	61.0 (50.0–66.8)	47.0 (44.2–49.5)	0.000020637	<0.001
	Inotrope dose T72 (mcg/kg/min)	0.00 (0.00–0.00)	0.08 (0.06–0.11)	0.00000000012	<0.001
Neurological	GCS T72	15.0 (13.8–15.0)	7.0 (4.2–9.0)	0.000000033	<0.001
Renal	Serum creatinine T72 (mg/dL)	0.79 (0.55–1.15)	2.72 (2.09–3.05)	0.000000440	<0.001
Overall	Total p-SOFA T72	4.0 (2.0–5.0)	18.0 (16.2–19.8)	0.0000000013	<0.001

Note: Values are presented as median (interquartile range). p-values were calculated using Mann-Whitney U test.

SpO_2 and PaO_2 are oxygenation variables used to assess the respiratory component of p-SOFA. Bicarbonate and lactate are not components of p-SOFA and are not included in this table. MAP: mean arterial pressure; GCS: Glasgow Coma Scale; p-SOFA: paediatric Sequential Organ Failure Assessment.

Admission, 72-hour and Delta p-SOFA by outcome

p-SOFA scores differed significantly between recovered children and deaths at both time points (Table 3). At admission, median p-SOFA was higher in the death group than in the recovered group. The separation became more pronounced at 72 hours. Delta p-SOFA was positive in recovered children, reflecting improvement, but negative in deaths which showed persistent or worsening organ dysfunction.

Table 3: Admission, 72-hour and Delta p-SOFA scores by outcome.

p-SOFA variable	Recovered (n=40)	Death (n=18)	p value
Admission p-SOFA (T0)	8.0 (6.0–9.2)	11.0 (10.2–13.8)	<0.001
72-hour p-SOFA (T72)	4.0 (2.0–5.0)	18.0 (16.2–19.8)	<0.001
Delta p-SOFA (T0–T72)	4.0 (1.8–6.0)	-6.0 (-6.8–-4.0)	<0.001

Values are median (interquartile range). Delta p-SOFA = admission p-SOFA (T0) - 72-hour p-SOFA (T72). A positive value - improvement; zero or negative value - no improvement or worsening.

The individual p-SOFA trajectories are shown in Figure 2. Most recovered children showed a downward trajectory between admission and 72 hours, whereas children who died had persistently high or increasing scores.

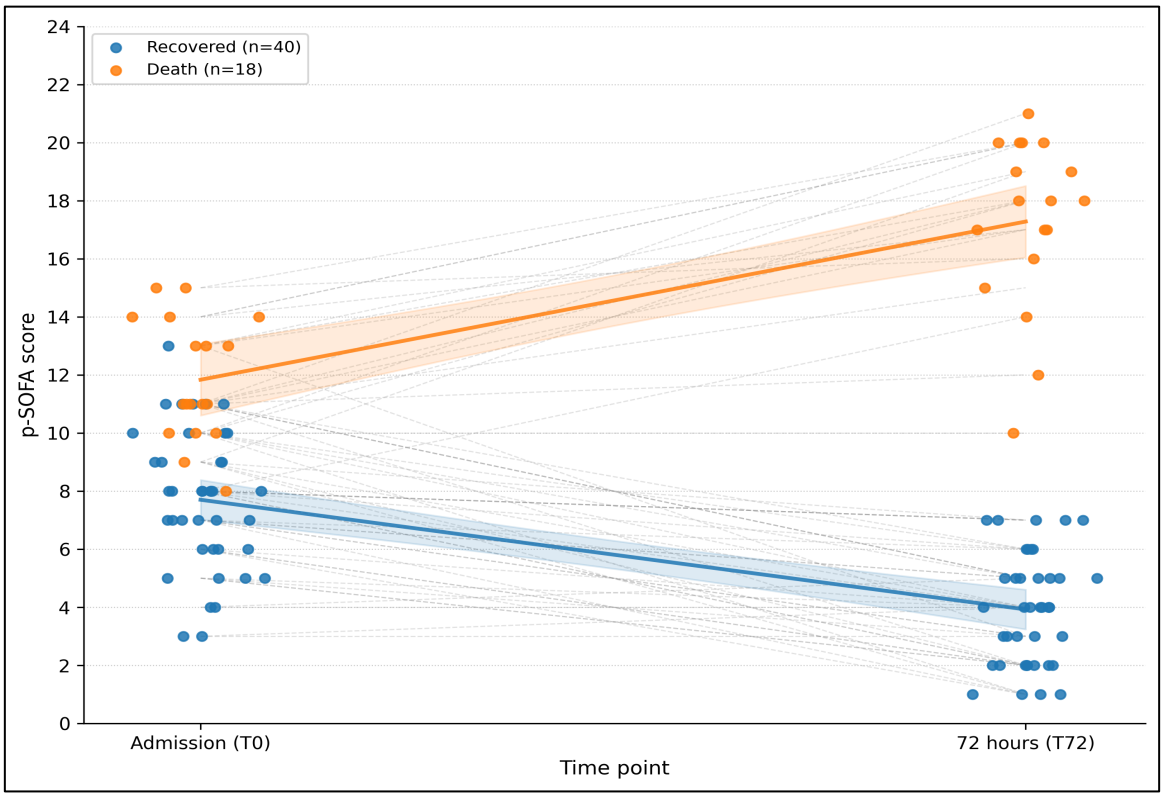


Figure 2: Individual p-SOFA scores at admission and 72 hours by outcome, with paired observations, fitted regression lines and 95% confidence bands.

Diagnostic performance of p-SOFA variables: The diagnostic performance of the three p-SOFA variables is shown in Table 4 and Figure 3. Admission p-SOFA showed excellent discrimination for mortality. A cut-off of >=10 had sensitivity of 88.9% and specificity of 75.0%. The 72-hour p-SOFA showed complete separation in this cohort at a cut-off of >=10. Delta p-SOFA also showed very high discrimination; a cut-off of <=0 identified mortality with 100.0% sensitivity and 90.0% specificity.

Table 4. Diagnostic performance of admission, 72-hour and Delta p-SOFA for mortality prediction.

Variable	AUC	95% CI	Cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Admission p-SOFA (T0)	0.899	0.809–0.966	≥10	88.9	75.0	61.5	93.8	79.3
72-hour p-SOFA (T72)	1.000	1.000–1.000	≥10	100.0	100.0	100.0	100.0	100.0
Delta p-SOFA (T0–T72)	0.993	0.978–1.000	≤0	100.0	90.0	81.8	100.0	93.1

AUC: area under the receiver operating characteristic curve; CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value.

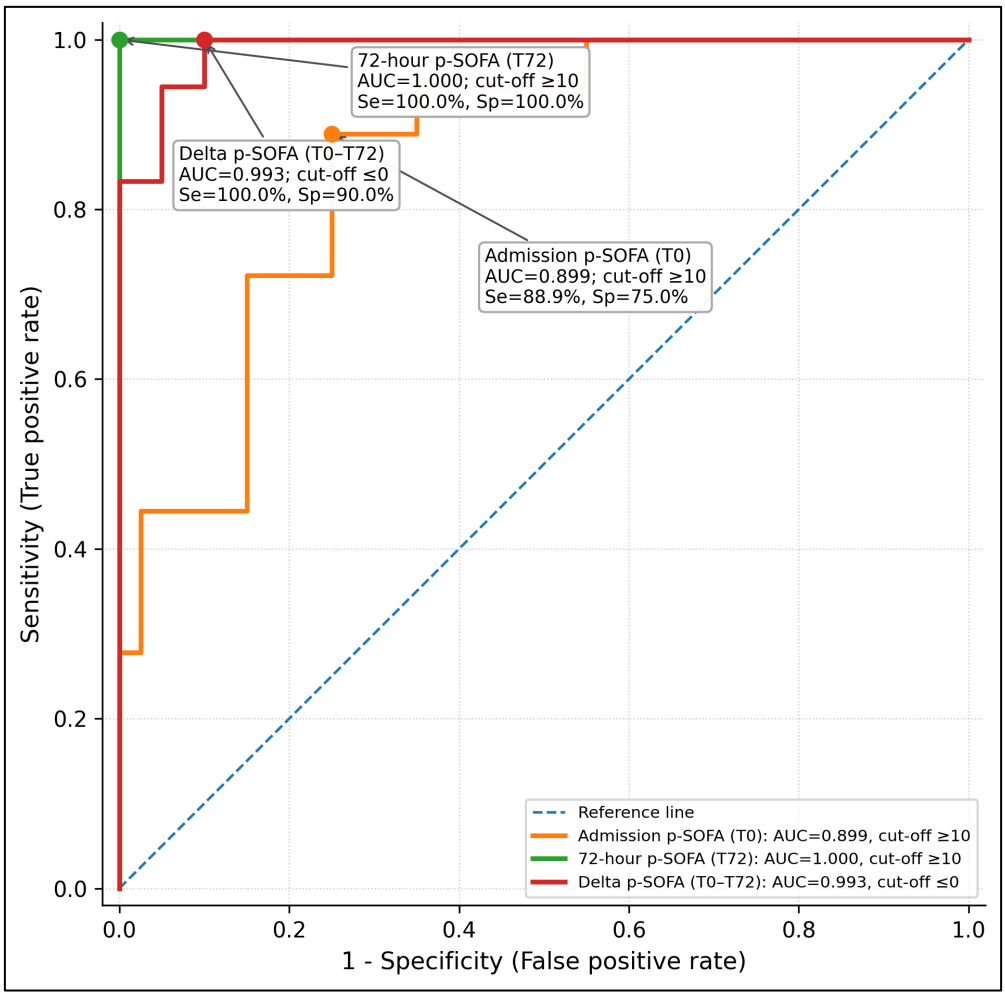


Figure 3: Receiver operating characteristic curves for admission p-SOFA, 72-hour p-SOFA and Delta p-SOFA for mortality prediction.

Discussion

The present study found that p-SOFA is a strong mortality prediction tool in children with sepsis admitted to PICU, but the most important finding is the added value of sequential assessment. Admission p-SOFA identified early risk, while 72-hour p-SOFA and Delta p-SOFA more clearly separated survivors from non-survivors. Children who recovered generally showed falling scores over 72 hours, whereas those who died had persistently high or worsening scores. This supports the concept that mortality risk in paediatric sepsis is better represented by the trajectory of organ dysfunction than by the baseline score alone.

The admission p-SOFA findings are clinically plausible. The score integrates respiratory, coagulation, hepatic, cardiovascular, neurological and renal dysfunction into a single bedside measure. In our cohort, non-survivors had lower SpO2, lower MAP, lower GCS, lower pH and bicarbonate, higher lactate and greater inotrope requirement at admission. These variables reflect the same physiological processes captured by p-SOFA: tissue hypoxia, shock, neurological compromise, metabolic acidosis and multi-organ

involvement. The admission cut-off of >=10 identified a high-risk group with 88.9% sensitivity and 75.0% specificity.

The stronger performance of 72-hour p-SOFA is the central clinical signal. Sepsis care is dynamic, and early therapy may change the course of organ dysfunction. A child with a high admission score may recover rapidly after fluids, antimicrobials, vasoactive support and ventilation, whereas a child with persistent dysfunction at 72 hours is likely to have ongoing inflammatory, microcirculatory or organ-support failure. Delta p-SOFA converts this clinical trajectory into a simple numeric marker: improvement produces a positive value, while no improvement or deterioration produces a zero or negative value. In this study, Delta p-SOFA <=0 had 100.0% sensitivity and 90.0% specificity, making it a practical bedside trigger for reassessment and escalation.

Comparison with Previous Studies: The present findings are consistent with the original paediatric adaptation and validation of p-SOFA by Matics and Sanchez-Pinto, which established the basis for age-adjusted organ dysfunction assessment in critically ill children [12]. Schlapbach et al. also demonstrated that age-adapted SOFA had prognostic accuracy for in-hospital mortality among children with suspected infection admitted to intensive care [13]. These studies support the biological and methodological rationale for using p-SOFA in paediatric sepsis.

Among direct p-SOFA studies, El-Mashad et al. reported an admission p-SOFA AUC of approximately 0.89 for 30-day mortality, which is almost identical to the admission AUC of 0.899 in our cohort [20]. Lalitha et al. reported that sequential scoring improved outcome prediction, supporting the present finding that T72 p-SOFA provides stronger prognostic information than T0 alone [21]. Balamuth et al. validated p-SOFA in a large paediatric emergency department suspected infection cohort, demonstrating broader applicability, although their population differed from our PICU-only sepsis cohort [22]. Baloch et al. also reported good performance of p-SOFA for PICU mortality prediction, supporting its feasibility in resource-constrained settings [23].

Recent studies further strengthen the serial-score argument. Agrwal et al. found that p-SOFA at 72 hours had strong predictive ability in a tertiary PICU setting [24]. Aggarwal et al. reported that p-SOFA at admission, 24 hours and 48 hours predicted mortality, with the strongest p-SOFA discrimination at 48 hours [25]. Our data extend this pattern to 72 hours and show that Delta p-SOFA provides an interpretable measure of treatment response. Hadzhieva-Hristova et al. found that p-SOFA performance varied when the endpoint was deterioration/complications rather than mortality, emphasizing that score performance depends on the target outcome and cohort characteristics [26]. Zhang et al. recently reported p-SOFA as a predictor of severity and outcome in critically ill children with sepsis, providing contemporary external support [27].

Table 5: Comparison of present study findings with published p-SOFA studies in paediatric sepsis and PICU cohorts.

Study	Design / population	Key p-SOFA finding	Contextual comparison with present study
Matics and Sanchez-Pinto, 2017 [12]	Retrospective validation in critically ill children	Adapted SOFA to paediatric physiology and evaluated Sepsis-3 definitions.	Provides the foundation for using p-SOFA domains and age-adjusted thresholds in this study.
Schlapbach et al., 2018 [13]	Multicentre registry study of children with suspected infection admitted to ICU	Age-adapted SOFA showed prognostic accuracy for in-hospital mortality.	Supports organ dysfunction-centred risk prediction; our study adds prospective serial T0-T72 assessment.
El-Mashad et al., 2020 [20]	Prospective two-centre PICU study	Admission p-SOFA predicted 30-day mortality with AUC about 0.89.	Our admission AUC of 0.899 is closely concordant and supports early p-SOFA risk stratification.
Lalitha et al., 2021 [21]	Prospective paediatric sepsis PICU study	Day 1 and day 3 p-SOFA discriminated outcomes; later scores improved interpretation.	Consistent with our finding that 72-hour p-SOFA outperformed admission p-SOFA.
Balamuth et al., 2022 [22]	Multicentre paediatric emergency department validation cohort	Validated p-SOFA in suspected infection and Sepsis-3-related paediatric assessment.	Demonstrates generalizability beyond PICU; our cohort is smaller but more clinically focused on admitted sepsis cases.
Baloch et al.,	Observational PICU	p-SOFA performed well for	Supports feasibility in resource-

2022 [23]	study	mortality prediction in critically ill children.	constrained settings, although not restricted to sepsis-only cohorts.
Agrwal et al., 2024 [24]	Prospective tertiary PICU study	p-SOFA at 72 hours had strong predictive ability; a 72-hour cut-off around 6.5 was reported.	Directly supports the central message that later p-SOFA assessment adds prognostic value.
Aggarwal et al., 2025 [25]	Prospective paediatric sepsis study	p-SOFA at 0, 24 and 48 hours predicted mortality; 48-hour p-SOFA AUC was 0.985.	Concordant with our very high T72 and Delta p-SOFA performance; both studies emphasize trajectory over baseline alone.
Hadzhieva-Hristova et al., 2025 [26]	Prospective PICU study comparing Phoenix score, p-SOFA, PELOD-2 and PRISM III	p-SOFA was useful for identifying patients without complications, while Phoenix score performed best for deterioration.	Highlights that p-SOFA performance varies by endpoint and case mix; our endpoint was mortality, not complications.
Zhang et al., 2025 [27]	Retrospective study of critically ill children with sepsis	p-SOFA predicted severity and in-hospital outcome with an optimal mortality threshold reported.	Adds recent external support for p-SOFA as a paediatric sepsis severity and outcome tool.

This table summarizes selected evidence used for contextual discussion. Study designs, endpoints and timing of p-SOFA assessment differ across studies; therefore comparisons should be interpreted qualitatively.

Clinical implications: The findings support a practical two-step use of p-SOFA in PICU sepsis care. First, admission p-SOFA can identify high-risk children early. Second, repeating p-SOFA at 72 hours and calculating Delta p-SOFA can help determine whether organ dysfunction is improving.

Persistent elevation or a Delta p-SOFA <=0 should prompt careful reassessment of source control, antimicrobial adequacy, haemodynamics, ventilation, renal function and neurological status. Newer Phoenix criteria and related work will continue to shape paediatric sepsis definitions and future comparative research, but p-SOFA remains a familiar and feasible bedside score [28,29]. Cardiovascular dysfunction is especially important in this context because hypotension and vasoactive requirement are central to p-SOFA scoring and to mortality risk in paediatric critical illness [30].

Strengths and limitations: The strengths of this study include its prospective design, clearly defined paediatric sepsis population, inclusion of the full paediatric age range from 1 month to 18 years, serial p-SOFA assessment at admission and 72 hours, and ROC-based evaluation of admission, 72-hour and Delta p-SOFA. The p-SOFA-only analysis also provides a focused message for clinical use.

The study has limitations. It was conducted at a single centre and included a modest sample size with 18 deaths. The apparent perfect separation observed for 72-hour p-SOFA may reflect cohort-specific features and should not be interpreted as a universally applicable performance estimate. Children with PICU stay less than 72 hours were excluded, which may introduce survival or selection bias. The cut-offs require validation in larger multicentre cohorts.

Treatment differences after admission, pathogen profile and comorbidities were not modelled in multivariable analysis because of the limited number of mortality events.

Conclusion

Admission p-SOFA is a useful tool for early mortality risk stratification in children with sepsis admitted to PICU.

However, sequential assessment provides stronger prognostic information. In this cohort, 72-hour p-SOFA and Delta p-SOFA showed excellent discrimination for mortality. Trajectory of organ dysfunction during the first 72 hours is highly clinically relevant. Serial p-SOFA monitoring is simple, reproducible and potentially useful for bedside reassessment and escalation decisions in paediatric sepsis.

Declarations

Ethics Approval: The study was conducted after approval from the Institutional Ethics Committee of Geetanjali Medical College and Hospital, Udaipur, Rajasthan. Approval number and date: to be inserted.

Consent: Written informed consent was obtained from the parents or guardians of all enrolled children.

Data Availability: The data underlying this manuscript may be made available by the corresponding author on reasonable request, subject to institutional and ethical approval.

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