CLINICAL INVESTIGATION ARTICLE

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The Phoenix Sepsis Score in Pediatric Oncology Patients With Sepsis at PICU Admission: Test of Performance in a European Multicenter Cohort, 2018–2020

OBJECTIVES: The Pediatric Sepsis Definition Task Force developed and validated a new organ dysfunction score, the Phoenix Sepsis Score (PSS), as a predictor of mortality in children with suspected or confirmed infection. The PSS showed improved performance compared with prior scores. However, the criteria were derived in a general pediatric population, in which only 10% had cancer. Given that pediatric cancer patients with sepsis have higher mortality compared with noncancer patients with sepsis, we aimed to assess the PSS in PICU patients with cancer and sepsis.

DESIGN: Retrospective multicenter cohort study.

SETTING: Twelve PICUs across Europe.

PATIENTS: Each PICU identified patients 18 years young or younger, with underlying malignancy and suspected or proven sepsis, and admission between January 1, 2018, and January 1, 2020.

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: The PSS and three other scores, including Phoenix-8, Pediatric Logistic Organ Dysfunction-2 (PELOD-2) score, and pediatric Sequential Organ Failure Assessment (pSOFA) score, were calculated for comparison. The primary outcome was 90-day all-cause mortality. We compared score performance using area under the receiver operating characteristic curve (AUROC) and area under the precision-recall curve (AUPRC) analyses. Among 383 patients with proven or suspected sepsis, 90-day mortality was 19.3% (74/383). We failed to identify an association between a particular score and performance for 90-day mortality. The mean (95% CI) values for the AUROC of each score was: PSS 0.66 (0.59–0.72), Phoenix-8 0.65 (0.58–0.72), PELOD-2 0.64 (0.57–0.71), and pSOFA 0.67 (0.60–0.74) and for the AUPRC of each score: PSS 0.32 (0.23–0.42), Phoenix-8 0.32 (0.23–0.42), PELOD-2 0.32 (0.22–0.43), and pSOFA 0.36 (0.26–0.46). Similar results were obtained for PICU mortality or sepsis-related PICU mortality.

CONCLUSIONS: Contrary to the general PICU population, our retrospective test of the PSS in a PICU oncology dataset with suspected or proved sepsis from European PICUs, 2018–2020, failed to identify improved performance in association with mortality. This unique patient population deserves development of organ dysfunction scores that reflect organ dysfunction and mortality data specifically from these patients and will require prospective validation in future studies.

KEYWORDS: cancer; children; organ dysfunction; sepsis

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In children with cancer, infection is the leading causes of noncancer-related mortality (1). We have previously shown in the 2018–2020 European Subphenotyping Children with Oncological diseases TrEated at the

RESEARCH IN CONTEXT

- Children with cancer are at high risk of sepsis-related death due to multiple organ dysfunction.
- The Pediatric Sepsis Definition Task Force developed and validated a new organ dysfunction score, the Phoenix Sepsis Score, as a predictor of mortality using data from more than 170,000 children with suspected infection. However, only 10% of these children had cancer.
- Given the high mortality rates of pediatric cancer patients with sepsis, there is a need for robust evaluation of organ dysfunction score performance in children with cancer with sepsis.

PICU for infections and inflammatory conditions: a Retrospective study (SCOTER) that pediatric cancer patients with sepsis admitted to the PICU had a 90-day mortality close to 30% (2). Children with cancer are also at high risk for organ dysfunction due to the cancer itself and the associated intensive treatment regimens that may lead to organ infiltration, systemic toxicity, and immunosuppression (3).

In January 2024, the Society of Critical Care Medicine Pediatric Sepsis Definition Task Force updated the criteria for sepsis and septic shock in children (4). The 2005 International Pediatric Sepsis Consensus Conference (IPSCC) criteria previously defined sepsis as a suspected or confirmed infection in the presence of the systemic inflammatory response syndrome (SIRS) (5). In contrast, the 2024 task force developed a data-driven sepsis-related organ dysfunction score, the Phoenix Sepsis Score (PSS), which focused on dysfunction of the respiratory, cardiovascular, coagulation, and/or neurological systems (6). A PSS of two or more identified sepsis among critically ill children with suspected or confirmed infection. The PSS was derived and validated using data from more than 170,000 children with suspected infection out of over 3.5 million pediatric patient encounters. That said, only 14,000 pediatric cancer patients (8%) were included (6). Therefore, the aim of our current work was to use the European SCOTER dataset to assess the performance of the PSS calculated from the first 24 hours of PICU admission data in discriminating 90-day or PICU mortality among PICU admissions with cancer and suspected or confirmed infection. Additionally, we compared the performance of the PSS with other existing scoring systems.

METHODS

We performed a post hoc, nonprespecified study of the SCOTER dataset (from January 1, 2018, to January 1, 2020) (2). This multicenter study included pediatric cancer patients with sepsis admitted to the PICUs of 12 participating hospitals from the PICU Oncology Kids in Europe Research (POKER) consortium, a working group of the European Society for Paediatric and Neonatal Intensive Care (ESPNIC). The inclusion criteria for the SCOTER study were: consecutive PICU admissions with age younger than 18 years, diagnosis of malignancy according to *International Classification of Diseases*, 10th Edition code, and suspected infection and SIRS according to the 2005 IPSCC criteria (5).

The original study protocol for the SCOTER study was approved by the central Institutional Review Board (IRB) at Wilhelmina Children's Hospital/University Medical Center Utrecht (IRB Number: 21-149/C. titled "Subphenotyping Children with Oncological disease TrEated at the PICU for inflammatory conditions: a Retrospective study [SCOTER], approved February 23, 2021) before study enrollment and has been previously published in detail (2). All subsequent research procedures were conducted in accordance with the ethical standard of the Helsinki Declaration of 1975.

Baseline demographic, clinical, and laboratory data were extracted in the original SCOTER study. Variables extracted from the electronic health records included a range of physiologic parameters about respiratory, cardiovascular, coagulation, neurologic, endocrine, immunologic, renal, and hepatic organ dysfunction status. The worst value during the first 24 hours of PICU admission was used. The PSS, Phoenix-8, Pediatric Logistic Organ Dysfunction-2 (PELOD-2), and pediatric Sequential Organ Failure Assessment (pSOFA) scores were calculated (4, 6–8). Where individual components of the scores were missing, no contribution was made to the total score (e.g., equivalent to assigning 0 or imputing a normal value).

Outcomes

The primary study outcome was all-cause 90-day mortality. The cause of death was categorized as

malignancy-related, toxicity-related, sepsis-related, or other. Secondary outcomes were PICU mortality and sepsis-related mortality.

Statistical Analysis

Data are presented as numbers, proportions, and percentages for categorical variables and medians with interquartile ranges (IQRs) for continuous variables. Discriminatory power was assessed by comparing the area under the receiver operating characteristic curve (AUROC). We estimated 95% CIs and compared AUROCs between scores using the DeLong method (9). Since the number of the survivors and nonsurvivors were unequal (unbalanced), we also computed area under the precision-recall curves (AUPRCs).

We assessed the contribution of individual organ systems for the prediction of the primary and secondary outcomes for the PSS, Phoenix-8, PELOD-2, and pSOFA scores, respectively. Each of the organ dysfunction subcomponent score was converted into a binary independent variable, that is, 0 if normal, or 1 if the subscore greater than or equal to 1. Logistic regression was used to assess the associations between the individual organ dysfunction and mortality. Sensitivity analysis was performed by including only patients with sepsis-related deaths. We used R, Version 4.2.1 for the statistical analyses (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

We included all 383 patients from the SCOTER study. The median age was 8.6 years (IQR, 3.7–13.9 yr), of which 217 of 383 (56.7%) were male (**Table 1**). Almost three-quarters of the patients had an underlying hematological malignancy (281/383). One hundred twelve patients (29.2%) had received hematopoietic cell transplantation (HCT). The 90-day mortality was 19.8% (76/383) and the median time to death was 12.5 days (IQR, 3.8–31.5 d).

TABLE 1.
Baseline Characteristics, Sepsis Scores, and Outcomes Among Pediatric Cancer Patients Admitted With Sepsis to PICU

Variables	All (*n* = 383)	Survivors (*n* = 309)	Nonsurvivors (*n* = 74)
Demographics			
Age, yr, median (IQR)	8.6 (3.7–13.9)	8.1 (3.2–13.5)	11.0 (4.6–15.0)
Sex, male, *n* (%)	217 (56.7)	176 (57.0)	41 (55.0)
Oncological diagnosis, *n* (%)			
Hemato-oncological	281 (73.4)	229 (74.1)	52 (70.3)
Solid tumor	48 (12.5)	34 (11.0)	14 (18.9)
Brain and CNS tumor	51 (13.3)	45 (14.6)	6 (8.1)
Other	3 (0.8)	1 (0.3)	2 (2.7)
Prior hematopoietic cell transplantation, *n* (%)	112 (29.2)	86 (27.8)	26 (35.1)
Sepsis scores on PICU admission, median (IQR)			
Phoenix Sepsis score	3 (1–4)	2 (1–4)	4 (2–5)
Phoenix-8 score	4 (2–6)	4 (2–5)	5 (3–7)
Pediatric Logistic Organ Dysfunction-2 score	6 (3–8)	6 (2–7)	7 (4–10)
Pediatric Sequential Organ Failure Assessment score	7 (4–10)	6 (3–9)	9 (5–12)
Organ support, *n* (%)			
Mechanical ventilation	185 (48.3)	128 (41.4)	57 (77.0)
Vasopressor use	195 (50.9)	141 (45.6)	54 (72.3)
Continuous renal replacement therapy	37 (9.7)	18 (5.8)	19 (26.7)
Extracorporeal membrane oxygenation	6 (1.6)	2 (0.6)	4 (5.4)

IQR = interquartile range.

PSS, Phoenix-8, PELOD-2, and pSOFA

The distribution of the four organ dysfunction scores and their relationship with 90-day mortality are shown in **Figures 1** and **2**. Distribution of different subcomponents and the portion of missing data are presented in **Figure S1** (http://links.lww.com/PCC/C589). Of the study cohort, 273 of 383 patients (71.3%) had a PSS greater than or equal to 2. There were 350 of 383 patients (91.4%) with a PELOD-2 score greater than or equal to 2 and 340 of 383 patients (88.8%) with a pSOFA score greater than or equal to 2.

The performance of the different scores in predicting the primary outcome all-cause 90-day mortality was poor with all AUROC values of less than 0.70 (**Table 2** and **Fig. 3**). We failed to identify whether PSS was associated with higher performance at discriminating 90-day mortality. The AUROC of PSS was 0.66 (95% CI, 0.59–0.72), compared with: Phoenix-8 0.65 (95% CI, 0.58–0.72; p = 0.64), PELOD-2 0.64 (95% CI, 0.57–0.71; p = 0.55), and pSOFA score 0.67 (95% CI, 0.60–0.74; p = 0.38). The performance using the AUPRC values was still moderate with AUPRC values between 0.32 and

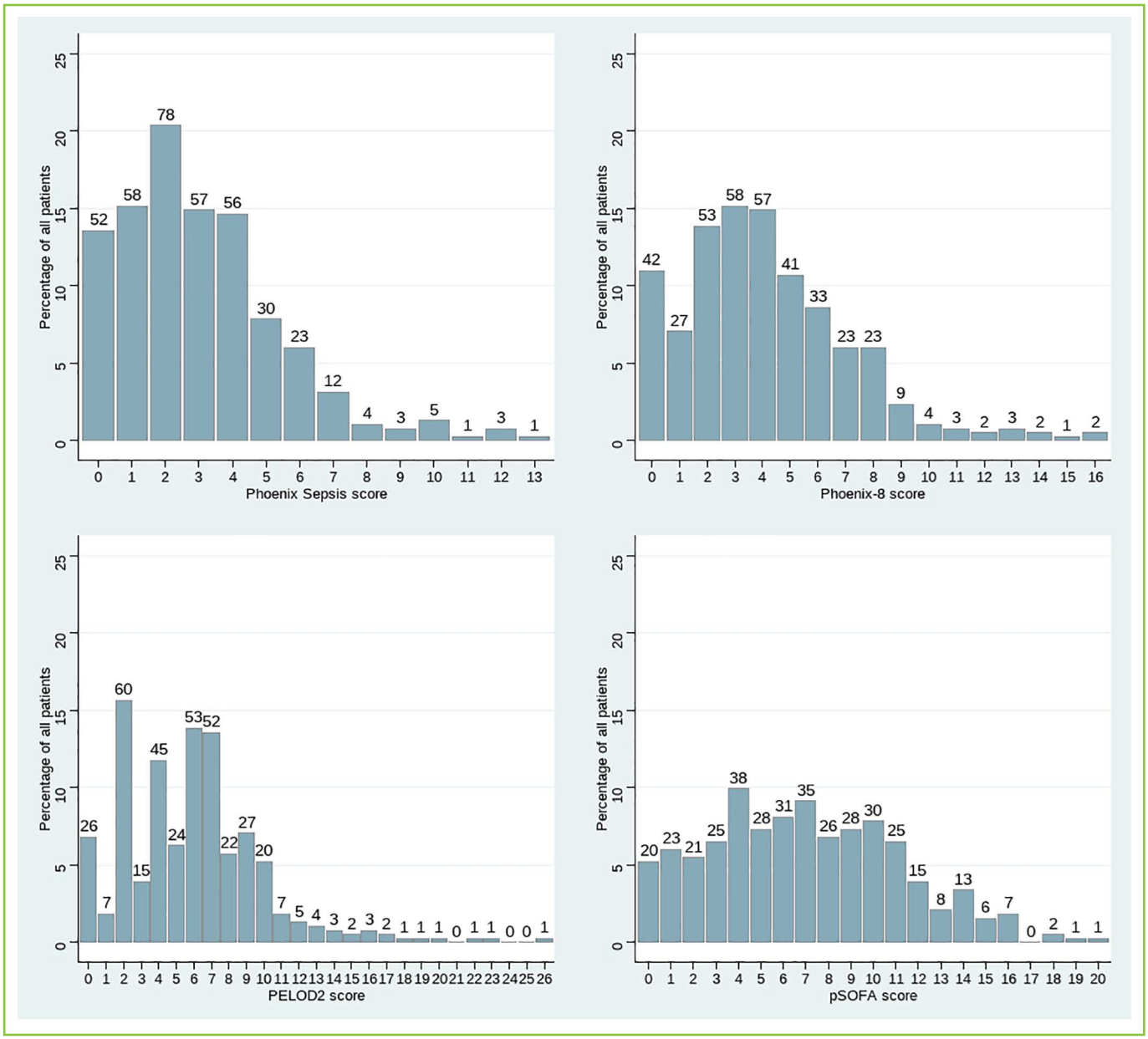

Figure 1. Distribution of patients by Phoenix Sepsis score, Phoenix-8 score, Pediatric Logistic Organ Dysfunction-2 (PELOD-2) score, and Pediatric Sequential Organ Failure Assessment (pSOFA) score on first 24 hr of PICU admission among pediatric cancer patients with sepsis (n = 383). Numbers above *bars* indicate numbers of patients per score.

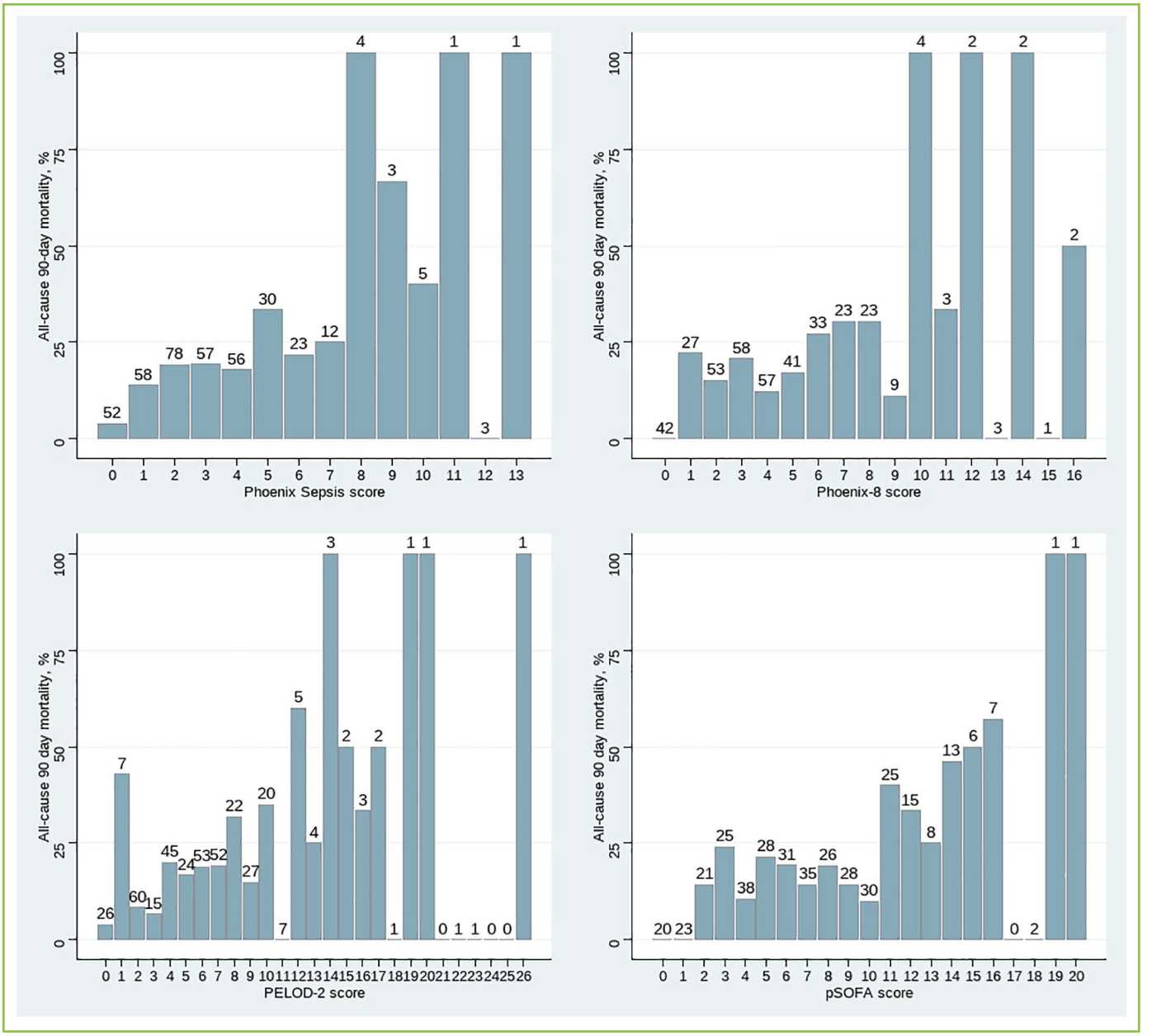

Figure 2. Mortality by Phoenix Sepsis score, Phoenix-8 score, Pediatric Logistic Organ Dysfunction-2 (PELOD-2) score, and Pediatric Sequential Organ Failure Assessment (pSOFA) score on first 24 hr of PICU admission among pediatric cancer patients with sepsis (n = 383). Numbers above *bars* indicate numbers of patients per score.

0.36 with a baseline mortality rate of 0.20 as reference (Table 2). The AUPRC of PSS was 0.32 (0.23–0.42), compared with: Phoenix-8 0.32 (0.23–0.42), PELOD-2 0.32 (0.23–0.43), and pSOFA score 0.36 (0.26–0.46). Similar discriminatory capacities were shown for the respective scores and PICU mortality (Table 2 and Fig. 3).

A sensitivity analysis including only patients with sepsis-related mortality resulted in improved performance of the scores at discriminating 90-day and PICU mortality, yet with AUROC values remained below 0.80 (Table 2; and **Fig. S2**, http://links.lww.com/PCC/C589).

Association of Individual Organ Dysfunctions With Mortality

We assessed the association of the individual subcomponents of the scores with mortality as defined by PSS and Phoenix-8 score, PELOD-2, and pSOFA for the primary outcome using logistic regression (**Table S1**, http://links.lww.com/PCC/C589). Respiratory and

TABLE 2.
Area Under the Receiver Operating Characteristic Curves and Area Under the Precision-Recall Curves for Discrimination Characteristics of Phoenix Sepsis, Phoenix-8, Pediatric Logistic Organ Dysfunction-2, and Pediatric Sequential Organ Failure Assessment Scores on PICU Admission for All-Cause and Sepsis-Related Mortality Among Pediatric Cancer Patients With Sepsis

Predictor	Area Under the Receiver Operating Characteristic Curve (95% CI)	Area Under the Precision-Recall Curve (95% CI)
All-cause 90-d mortality		
Phoenix Sepsis score	0.66 (0.59–0.72)	0.32 (0.23–0.42)
Phoenix-8 score	0.65 (0.58–0.72)	0.32 (0.23–0.42)
PELOD-2 score	0.64 (0.57–0.71)	0.32 (0.22–0.43)
pSOFA score	0.67 (0.60–0.74)	0.36 (0.26–0.46)
All-cause PICU mortality		
Phoenix Sepsis score	0.72 (0.65–0.79)	0.32 (0.21–0.45)
Phoenix-8 score	0.71 (0.63–0.78)	0.32 (0.21–0.45)
PELOD-2 score	0.70 (0.63–0.78)	0.32 (0.21–0.45)
pSOFA score	0.72 (0.64–0.79)	0.36 (0.25–0.48)
Sepsis-related 90-d mortality		
Phoenix Sepsis score	0.72 (0.64–0.80)	0.29 (0.17–0.42)
Phoenix-8 score	0.71 (0.63–0.80)	0.29 (0.18–0.43)
PELOD-2 score	0.72 (0.64–0.81)	0.31 (0.18–0.45)
pSOFA score	0.74 (0.65–0.83)	0.40 (0.25–0.54)
Sepsis-related PICU mortality		
Phoenix Sepsis score	0.74 (0.66–0.82)	0.29 (0.17–0.44)
Phoenix-8 score	0.74 (0.65–0.82)	0.29 (0.18–0.45)
PELOD-2 score	0.74 (0.66–0.82)	0.30 (0.18–0.46)
pSOFA score	0.76 (0.67–0.85)	0.41 (0.25–0.56)

PELOD-2 = Pediatric Logistic Organ Dysfunction-2, pSOFA = pediatric Sequential Organ Failure Assessment.

renal dysfunction were the most relevant organ dysfunctions across most scores, while cardiovascular dysfunction was in the Phoenix scores but not in PELOD-2 and pSOFA scores.

DISCUSSION

In this retrospective analysis of the European SCOTER 2018–2020 dataset of 383 pediatric cancer patients admitted to PICU with sepsis, we found that the prognostic accuracy of the PSS, Phoenix-8, PELOD-2, and pSOFA scores was poor for 90-day all-cause-mortality and still less than acceptable for PICU mortality, respectively.

Our findings appear to contrast with the performance of these scores in the general pediatric population. For example, to date, a number of studies have demonstrated good to excellent prognostic accuracy for in-hospital, PICU or 30-day mortality, across various datasets from high- and less-resourced settings, and the PICU and emergency department settings (6, 8, 10, 11). However, the current findings corroborate a U.S. report from a quaternary single center retrospective cohort (2013–2019) on the prognostic performance of the scores in the pediatric cancer and post-HCT population with sepsis, showing poor discrimination of several sepsis scores at the time of PICU admission for all-cause mortality (12). In our study, the performance of all investigated scores was similar both in relation to AUROC as well as in relation to AUPRC. Importantly, the numbers in the U.S. study were relatively small with mortality in 17 of 171 episodes (9.9%) or 17 of

AT THE BEDSIDE

- In this retrospective multicenter study, the prognostic accuracy of the Phoenix Sepsis Score was poor for 90-day all-cause-mortality and less than acceptable for PICU mortality in children with cancer admitted to PICU with sepsis.
- Additionally, we found similar poor discriminatory capacities for other organ dysfunction scores, including Phoenix-8, Pediatric Logistic Organ Dysfunction-2, and pediatric Sequential Organ Failure Assessment scores.
- Applying scoring systems to particular high-comorbid groups (which increasingly characterize the PICU patient population) is challenging and may serve to feed into the controversy around the uptake of the Phoenix criteria.

143 patients (11.9%). These percentages are lower than the SCOTER dataset 90-day mortality (76/383, 19.8%) and suggest that the U.S cohort comprised less sick patients compared with the European SCOTER cohort. The relatively large proportion of patients with later mortality (i.e., after the first week of PICU) may suggest that secondary infections, other PICU-related complications, and sequelae from the underlying disease and its treatment may contribute to mortality in these patients instead of acute and direct sepsis-related refractory multiple organ failure or shock. Of note, in an Australia and New Zealand cohort from 2012 to 2015, the median time to death in children with sepsis without comorbidities was short as 1.9 days from PICU admission (13), which is very different to the SCOTER 2018–2020 cohort with 12.5 days to death; thus, the temporal proximity of the time of prediction with the predicted event (death) may partially explain the relatively poor diagnostic performance in our study.

The currently used sepsis scores are based on organ dysfunction at PICU admission where organ dysfunction is assumed to be related to infection by temporal association. A possible explanation for the poor performance of the sepsis scores in pediatric cancer patients is that organ dysfunction at PICU admission is not entirely attributable to infection-related critical illness but indicates a composite of critical illness, cancer itself, and/or toxicity of cancer treatment with different pathophysiology and outcomes, thus affecting mortality prediction. We categorized the cause of mortality as malignancy-related, toxicity-related, sepsis-related, or other. The performance of the scores in a subcohort of patients with sepsis-related mortality improved minimally compared with the performance for all-cause mortality, suggesting that causes of mortality may not be mutually exclusive in these patients. Malignancy as a cause of death may be caused by postponing cancer treatment during the sepsis period. Toxicity as a cause may be influenced by pre-admission toxicity due to cancer treatment and additional organ injury due to sepsis. Therefore, criteria for organ dysfunction in critically ill general pediatric patients may not be generalizable to pediatric cancer patients. Furthermore, some organ failures such as coagulation failure or thrombocytopenia may be nondiscriminative of outcomes in oncologic patients, as opposed to nononcologic PICU patients.

Interestingly, the association between the individual subcomponents

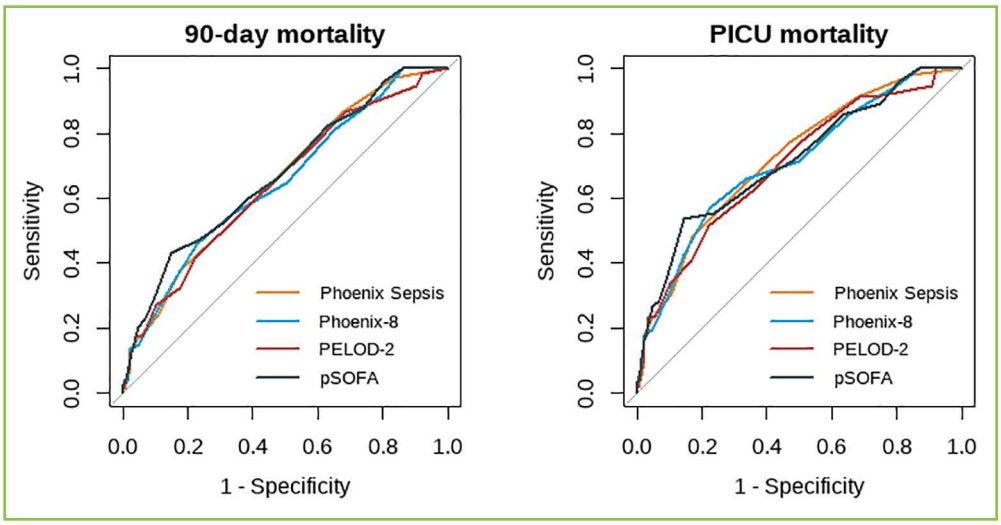

Figure 3. Area under the receiver operating characteristic curves for discriminatory capacity for 90-d mortality and PICU mortality for Phoenix Sepsis score, Phoenix-8 score, Pediatric Logistic Organ Dysfunction-2 (PELOD-2) score, and Pediatric Sequential Organ Failure Assessment (pSOFA) score on first 24 hr of PICU admission among pediatric cancer patients with sepsis.

of the scores and mortality differs between the PSS and Phoenix-8 scores compared with PELOD-2 and pSOFA. Pulmonary complications are a well-known major risk factor for mortality in pediatric cancer and HCT patients, which may be reflected by the association of respiratory dysfunction and mortality observed across all scores. In contrast, cardiovascular dysfunction shows a significant association with mortality in the Phoenix scores but not in PELOD-2 or pSOFA. This difference may be explained by variations in the criteria used by each scoring system. The Phoenix scores include vasoactive medication use, lactate levels, and mean arterial pressure, while PELOD-2 includes only lactate levels and mean arterial pressure, and pSOFA includes mean arterial pressure and vasoactive medication use.

Our study has several limitations. Although we used routinely collected electronic health record data from a large multicenter cohort of critically ill pediatric cancer patients, the numbers are still small. We used the worst physiological and laboratory values within the first 24 hours of PICU admission, which might not be directly linked to the timing of the diagnosis of infection. In many pediatric cancer patients, sepsis often begins while they are still in the ward, and organ dysfunction may also develop during this period before PICU admission. Therefore, the performance of the scoring systems might improve if data from the period prior to PICU admission were included. However, our approach was similar to the approach used for the derivation and validation of the different sepsis scores in the general pediatric population (6–8). Additionally, data for calculating the scores were missing in more than 10% of the patients, which may have resulted in an underestimation of the performance of the scores. A prospective study with a large sample size on the performance of the scores is needed to robustly determine the scores' prognostic accuracy.

Children with cancer are at high risk of sepsis and organ dysfunction, with increasing rates of PICU admission over the period, 2003–2018 and 2012–2021 (14, 15). The current 2018–2020 SCOTER study demonstrates that the performance of the currently available sepsis scores, including the 2024 PSS to predict mortality, is poor. Development of more prediction tools for this specific patient population is important for identifying high-risk patients, guiding escalation of treatment, allowing enrollment in research, and ultimately driving outcome improvement.

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Members of the PICU Oncology Kids in Europe Research (POKER) group research consortium of European Society for Paediatric and Neonatal Intensive Care (ESPNIC) are listed in the ***Supplementary Appendix*** *(http://links.lww.com/PCC/C589).*

REFERENCES

1. Loeffen EAH, Knops RRG, Boerhoef J, et al: Treatment-related mortality in children with cancer: Prevalence and risk factors. *Eur J Cancer* 2019; 121:113–122
2. Wösten-van Asperen RM, la Roi-Teeuw HM, van Amstel RB, et al; POKER (PICU Oncology Kids in Europe Research group) research consortium of ESPNIC (European Society of Paediatric & Neonatal Intensive Care), and; Novel Data-Driven Sepsis Phenotypes in Children study group: Distinct clinical phenotypes in paediatric cancer patients with sepsis are associated with different outcomes—an international multicentre retrospective study. *EClinicalMedicine* 2023; 65:102252
3. Soeteman M, Fiocco MF, Nijman J, et al: Prognostic factors for multi-organ dysfunction in pediatric oncology patients admitted to the pediatric intensive care unit. *Front Oncol* 2023; 13:1192806
4. Schlapbach LJ, Watson RS, Sorce LR, et al; Society of Critical Care Medicine Pediatric Sepsis Definition Task Force: International consensus criteria for pediatric sepsis and septic shock. *JAMA* 2024; 331:665–674
5. Goldstein B, Giroir B, Randolph A; International Consensus Conference on Pediatric Sepsis: International Pediatric Sepsis Consensus Conference: Definitions for sepsis and organ dysfunction in pediatrics. *Pediatr Crit Care Med* 2005; 6:2–8
6. Sanchez-Pinto LN, Bennett TD, DeWitt PE, et al; Society of Critical Care Medicine Pediatric Sepsis Definition Task Force: Development and validation of the Phoenix criteria for pediatric sepsis and septic shock. *JAMA* 2024; 331:675–686
7. Leteurtre S, Duhamel A, Salleron J, et al; Groupe Francophone de Réanimation et d'Urgences Pédiatriques (GFRUP): PELOD-2: An update of the Pediatric Logistic Organ Dysfunction score. *Crit Care Med* 2013; 41:1761–1773
8. Matics TJ, Sanchez-Pinto LN: Adaptation and validation of a pediatric Sequential Organ Failure Assessment score and evaluation of the Sepsis-3 definitions in critically ill children. *JAMA Pediatr* 2017; 171:e172352
9. DeLong ER, DeLong DM, Clarke-Pearson DL: Comparing the areas under two or more correlated receiver operating characteristic curves: A nonparametric approach. *Biometrics* 1988; 44:837–845
10. Schlapbach LJ, Straney L, Bellomo R, et al: Prognostic accuracy of age-adapted SOFA, SIRS, PELOD-2, and qSOFA for in-hospital mortality among children with suspected infection admitted to the intensive care unit. *Intensive Care Med* 2018; 44:179–188
11. Schlapbach LJ, Goertz S, Hagenbuch N, et al; Swiss Pediatric Sepsis Study Group: Organ dysfunction in children with blood culture-proven sepsis: Comparative performance of four scores in a National Cohort Study. *Pediatr Crit Care Med* 2024; 25:e117–e128
12. Wolf J, Rubnitz Z, Agulnik A, et al: Phoenix sepsis score and risk of attributable mortality in children with cancer. *JAMA Netw Open* 2024; 7:e2415917
13. Schlapbach LJ, MacLaren G, Festa M, et al; Australian & New Zealand Intensive Care Society (ANZICS) Centre for Outcomes & Resource Evaluation (CORE) and Australian & New Zealand Intensive Care Society (ANZICS) Paediatric Study Group: Prediction of pediatric sepsis mortality within 1 h of intensive care admission. *Intensive Care Med* 2017; 43:1085–1096
14. Wraight TI, Namachivayam SP, Maiden MJ, et al; Australian and New Zealand Intensive Care Society Paediatric Study Group and Centre for Outcome and Resource Evaluation: Trends in childhood oncology admissions to ICUs in Australia and New Zealand. *Pediatr Crit Care Med* 2023; 24:e487–e497
15. Rogerson CM, Rowan CM: Critical care utilization in children with cancer: U.S. Pediatric Health Information System Database Cohort 2012-2021. *Pediatr Crit Care Med* 2024; 25:e52–e58