

JPPT | Single Center Retrospective Study

Pharmacist Metrics in the Pediatric Intensive Care Unit: an Exploration of the Medication Regimen Complexity-Intensive Care Unit (MRC-ICU) Score

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INTRODUCTION The medication regimen complexity-intensive care unit (MRC-ICU) score has been developed and validated as an objective predictive metric for patient outcomes and pharmacist workload in the adult critically ill population. The purpose of this study was to explore the MRC-ICU and other workload metrics in the pediatric ICU (PICU).

METHODS This study was a retrospective cohort of pediatric ICU patients admitted to a single institution between February 2, 2022 – August 2, 2022. Two scores were calculated, including the MRC-ICU and the pediatric Daily Monitoring System (pDMS). Data were extracted from the electronic health record. The primary outcome was the correlation of the MRC-ICU to mortality, as measured by Pearson correlation coefficient. Additionally, the correlation of MRC-ICU to number of orders was evaluated. Secondary analyses explored the correlation of the MRC-ICU with pDMS and with hospital and ICU length of stay.

RESULTS A total of 2,232 patients were included comprising 2,405 encounters. The average age was 6.9 years (standard deviation [SD] 6.3 years). The average MRC-ICU score was 3.0 (SD 3.8). For the primary outcome, MRC-ICU was significantly positively correlated to mortality (0.22 95% confidence interval [CI 0.18 – 0.26]), $p < 0.05$. Additionally, MRC-ICU was significantly positively correlated to ICU length of stay (0.38 [CI 0.34 – 0.41]), $p < 0.05$. The correlation between the MRC-ICU and pDMS was (0.72 [CI 0.70 – 0.73]), $p < 0.05$.

CONCLUSION In this pilot study, MRC-ICU demonstrated an association with existing prioritization metrics and with mortality and length of ICU stay in PICU population. Further, larger scale studies are required.

ABBREVIATIONS AHFS, American Hospital Formulary Service; ATC, anatomical therapeutic chemical; APACHE, acute physiology and chronic health evaluation; CI, confidence interval; EHR, electronic health record; ECMO, extracorporeal membrane oxygenation; LVAD, left ventricular assist devices; MRC-ICU, medication regimen complexity-intensive care unit; ICU, intensive care unit; PICU, pediatric intensive care unit; pDMS, pediatric daily monitoring system; REMS, risk evaluation mitigation strategies; SD, standard deviation; SQL, structured query language; TPN, total parenteral nutrition.

KEYWORDS critical care; pharmacy; pediatrics; medication regimen complexity; pharmacists; informatics

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Introduction

Metrics that quantify and predict pharmacist workload have the potential to improve patient care delivery by optimization of pharmacist workload, thus ensuring that each critically ill patient receives the care of a critical care pharmacist.^{1,2} Moreover, metrics can help to prioritize daily workflow for clinical pharmacists such that they review the patients with the highest need for their cognitive services first.³

The medication regimen complexity-intensive care unit (MRC-ICU) Scoring Tool is the first metric designed specifically for critical care pharmacy practice with the goal of describing critical care pharmacist workload in

the adult population.^{1–10} In adults, this metric has shown promise with its relationship to both patient outcomes and pharmacist workload. The MRC-ICU correlated with severity of illness (as measured by the Acute Physiology and Chronic Health Evaluation (APACHE) III), patient-centered outcomes (e.g., mortality and length of stay), ICU-related complications (e.g., fluid overload and drug-drug interactions), and pharmacist workload, as measured by documented pharmacist interventions.^{2–10} However, it is well known that adult and pediatric patient populations differ significantly with representative guidelines for those differences in care, including in the domain of critical care.^{11,12}

The purpose of this study was to validate the MRC-ICU in a pediatric population by assessing its relationship to patient-centered outcomes (i.e., mortality, length of stay) and its convergent and divergent association to existing measures of pharmacy workload.

Methods

Study Design. This study was conducted at a large pediatric health system in the greater Atlanta area with more than 2,600 pediatric providers and 638 licensed beds. Data from all patients' encounters including demographics, medication administrations, flags for dialysis, ECMO, Mechanical Ventilation as well as their outcomes, length of stay, mortality, were retrospectively extracted for a 6-month period between February 2, 2022, and August 2, 2022, using query of the electronic health record.

Pediatric Daily Monitoring System Development.

A local scoring tool was developed based on group consensus of pediatric clinical pharmacists in conjunction with the informatics system pharmacists. The goal of this score was to support clinical pharmacist prioritization during their comprehensive therapeutic review of patients. The tool was designed to support clinical pharmacists in managing their daily workflow by helping quickly identify those patients that require increased or more thorough monitoring. The tool is comprised of eight categories including: 1. Medications requiring pharmacokinetics; 2. Sedation; 3. Anticoagulation; 4. Nephrotoxicity; 5. Immunosuppressants; 6. Anticonvulsants; 7. Medications requiring Risk Evaluation and Mitigation Strategies (REMS) programs; 8. Intravenous (IV) to oral (PO) transition. Within each category, there are individual line items that are weighted. For example, under medications requiring pharmacokinetics, the medication 'vancomycin' is awarded one point. The sum of each category is also applied a weight, and this total value is then assigned one of four color-coded categories: 1-5 (green), 6-12 (yellow), 13-18 (red), and >18 (critical, dark red). The score is described in Table S1. The coloring scheme served as a visual indicator of a patient's "total acuity". Patients with high "total acuity" receive a crimson or red icon, patients with moderate acuity received yellow and green represented patients with modest acuity. These patients represent patients whose overall clinical picture presents the greatest opportunity for clinical pharmacy intervention. As such, the tool is a quick visual cue for the pharmacist in addition to a more granular breakdown of medication regimen components. The tool was built within the EHR and is available as a score within patient flowsheet (Figure).

MRC-ICU Scoring Tool Adaptation. The MRC-ICU is a 37-line-item score calculated at a given time point where each medication included in the score that is prescribed to a patient is assigned a weighted value

ranging from 1-3.⁴⁻¹¹ These values are then summed to provide the total score. For example, a patient receiving meropenem (2 points), tobramycin (3 points), norepinephrine (1 point), and vasopressin (1 point) on ICU Day 2, would have a day 2 MRC-ICU score of 7. The goal was to replicate all the elements included in the original MRC-ICU study as closely as possible for validation in the pediatric population at this institution. There were certain elements in the scoring tool that were not applicable to the workflow for pediatric care at our health system. Hence, we used a modified version of the MRC-ICU specifically adapted for the pediatric population. Changes to the original calculations included (1) exclusion of chlorhexidine because this is not used for ventilator prophylaxis; (2) Clinical dieticians order TPNs for patients, the staff/TPN pharmacist verifies the TPN order, and they will usually reach out to the dietician if there is an issue with the TPN order. The pharmacy specialist is typically not involved in the ordering or review process. Pharmacists do review labs for electrolyte imbalances (especially if patients are on diuretics), the staff pharmacist covering the TPN shift is responsible for verifying and compounding the TPN. Since clinical pharmacists *are* involved in reviewing electrolyte imbalances but not in the ordering or verification of the TPN, 2 points were assigned for TPN management; (3) to reflect pediatric practices for opioids and sedatives, 2 points were assigned for each continuous infusion and 1 point for patients receiving scheduled intermittent doses; (4) enoxaparin doses >1.75 mg/kg/day were considered therapeutic heparins; (5) exclusion of left ventricular assist devices (LVADs) as pediatric patients with LVADs at our institution are not cared for in the PICU. Each element in the MRC-ICU score was extracted from the Epic Clarity® database using Structured Query Language (SQL) queries. The validity of data capture for devices was verified on 5 random patients. To capture each medication, a Pharmacy Informaticist (KH) developed a set of identifiers that captured the medications in the formulary. These included a set of

1. American Hospital Formulary Service (AHFS) codes,¹³
2. Anatomical Therapeutic Chemical (ATC) Codes,¹⁴
3. Epic® and First DataBank®-specific identifiers (including unique medication records and assigned pharmaceutical classes).

This list was then checked for accuracy and was updated on review by another Pharmacy Informaticist (TD). The queries built based on the identifiers were verified using two approaches

- (1) the relative total number of medications identified by the query was checked to see if it matches anecdotal evidence of usage of these meds
- (2) five patient charts were reviewed to validate accuracy of the medications pulled by the query

Figure. Screenshot of the Pediatric Daily Monitoring System

Total Acuity Score	Rx Consults	Kinetics	Anti-coag	I-Vents	Anti-convulsants	Add'l Kinetics	Immuno-suppressants	Creatinine Change	RX New Result	Antimicrobial 24 hr	Antimicrobial 48 hr	Antimicrobial	REMS	Sedation/W	NINJA	Covid Therapies	Recent Transfer	Rx To Do
3											☒	☒		○				{}
12	☒										☒	☒		○				{}
0																		{}
0																		{}
7												☒						{}
—	0	0	0	0	0	0	0						0	0	0	0	0	—
1					○													{}
—	0	0	0	0	0	0	0						0	0	0	0	0	—
0																		{}
7	☒										☒	☒		○				{}
6	☒										☒	☒		○				{}
0											☒	☒						{}
0																		{}
0								●				☒						{}
4												☒						{}

The color schema for Total Acuity Score is described in the methods section. See table S1 below for description of scores, including total acuity score. For Kinetics, Anti-coag, Anticonvulsants, and Add'l kinetics columns, presence of an icon in column indicates a score for that parameter. Additional columns of scoring system (not shown above) follow similar schema. Icons in RX consults and I-vents columns indicate the presence of specific procedure orders and clinical notations relevant to pharmacy workflow, respectively.

against chart documentation. The components used for the MRC-ICU and their weightage for the scoring tool are described in Table S2.

Primary and Secondary Outcomes. The primary outcome of this study was the correlation of the MRC-ICU measured at 24 hours to mortality. Secondary outcomes included the correlation of the MRC-ICU with ICU and hospital length of stay. Finally, in line with the historical validation of MRC-ICU, convergent validity was assessed with number of medication orders for a patient at 24 hours, and divergent validity was assessed with correlation to patient age. All of these analyses were repeated for the institutionally employed pediatric Daily Monitoring Score (pDMS). Additionally, the correlation of the MRC-ICU and pDMS was assessed.

Statistical Analysis. All statistical analyses were performed using R version 3.6.3. Descriptive statistics were applied to this dataset, and all data are described as mean (standard deviation) and n (percent) unless otherwise stated. Statistical significance was assessed at 0.05.

Pearson correlation was calculated between MRC-ICU and pDMS scores with total number of medications and total number of orders was used to examine convergent validity. Additionally, divergent validity was assessed by correlation of the two scores with age. Logistic regression was applied to identify log odds of MRC-ICU and pediatric Daily Monitoring System association with mortality. Similarly, linear regression was applied to identify the relationship between continuous outcomes (number of patient medication orders, hospital length of stay, ICU length of stay) and the two scoring tools.

Results

A total of 2,239 patients comprising 2,405 encounters were included. The average age was 6.9 years (SD 6.3), and the population was 54.4% male. Overall, the mortality rate was 1.95%, and the average ICU length of stay was 94.7 hours (SD 142.4). The mean MRC-ICU score was 3.0 (SD 3.8), and the mean pDMS was 1.9 (SD 3.0). Complete results can be found summarized in Table 1.

For the primary outcome, MRC-ICU demonstrated significant correlation to mortality as measured by

Pearson correlation (0.22 [CI 0.18 – 0.26]), $p < 0.05$. Additionally, MRC-ICU showed significant correlation with hospital length of stay (0.36 [CI 0.32 – 0.39]), $p < 0.05$ as well as ICU length of stay (0.38 [CI 0.34 – 0.41]), $p < 0.05$. Moreover, it showed appropriate convergent validity with number of orders (0.51 [CI 0.48 – 0.54]), $p < 0.05$ and number of medications (0.65 [CI 0.63 – 0.68]), $p < 0.05$. Further, it showed divergent validity with patient sex (0.02 [CI –0.02 – 0.06]), $p = 0.40$. But divergent validity was not found with patient age (0.12 [CI 0.08 – 0.16]), $p < 0.05$ as well as with weight (0.08 [CI 0.04 – 0.12]), $p < 0.05$. Complete results are summarized in Table 2.

pDMS also demonstrated significant correlation to mortality as measured by Pearson correlation (0.17 [0.13 – 0.21]), $p < 0.05$. Additionally, it showed significant correlation with hospital length of stay (0.33 [CI 0.29 – 0.36]), $p < 0.05$ and ICU length of stay (0.27 [CI 0.24 – 0.31]), $p < 0.05$. pDMS showed appropriate convergent validity with number of orders (0.47 [CI 0.44 – 0.50]), $p < 0.05$, and number of medications (0.55 [CI 0.52 – 0.58]), $p < 0.05$. Further, it showed divergent validity with patient sex (–0.01 [CI 0.05 – 0.03]), $p = 0.8$. Divergent validity was not found with patient age (0.16 [CI 0.12 – 0.20]), $p < 0.05$ as well as with weight (0.11 [CI 0.07 – 0.15]), $p < 0.05$. Finally, the

Table 1. Summary of demographic and outcome characteristics

Characteristic	2,405 Encounters
Demographics	
Age, Years	6.9 (6.3)
Sex (male)	1308 (54.4%)
Outcomes	
Mortality	47 (1.95%)
Length of stay (hrs.)	215.1 (411.2)
ICU length of stay (hrs.)	94.7 (142.4)
Number of medication orders	68.5 (115.8)
Number of medications	28.7 (25.5)
Metrics	
MRC-ICU at 24 hours	3.0 (3.8)
pDMS at 24 hours	1.9 (3.0)

Data are presented as mean (standard deviation) except Sex and Mortality which are expressed as n (percent)

ICU = intensive care unit; MRC-ICU – medication regimen complexity intensive care unit; PDMS = pediatric daily monitoring system

Table 3. Relationship of pharmacy metrics using regression analysis

Outcome	Score	Coefficient Estimate	Std Error	p-value
Mortality	MRC-ICU	0.23	0.03	<0.005
	pDMS	0.19	0.03	<0.005
Hospital Length of stay	MRC-ICU	38.44	2.12	<0.005
	pDMS	44.47	2.68	<0.005
ICU length of stay	MRC-ICU	14.40	0.72	<0.005
	pDMS	13.25	0.93	<0.005

For binary outcome (Mortality) coefficient estimate corresponds to logistic regression

For continuous outcomes coefficient estimate corresponds to linear regression

Table 2. Validation of pharmacy metrics using correlation analysis

	MRC-ICU	p-value	pDMS	p-value
Mortality	0.22 (0.18 – 0.26)	<0.05	0.17 (0.13 – 0.21)	<0.05
ICU Length of stay	0.38 (0.34 – 0.41)	<0.05	0.27 (0.24 – 0.31)	<0.05
Hospital length of stay	0.36 (0.32 – 0.39)	<0.05	0.33 (0.29 – 0.36)	<0.05
Number of medication orders	0.51 (0.48 – 0.54)	<0.05	0.47 (0.44 – 0.50)	<0.05
Number of medications	0.65 (0.63 – 0.68)	<0.05	0.55 (0.52 – 0.58)	<0.05
Age	0.12 (0.08 – 0.16)	<0.05	0.16 (0.12 – 0.20)	<0.05
Weight	0.08 (0.04 – 0.12)	<0.05	0.11 (0.07 – 0.15)	<0.05
Sex	0.02 (0.02 – 0.06)	0.40	–0.01 (–0.05 – 0.03)	0.80
MRC-ICU	—	—	0.72 (0.70 – 0.73)	<0.05
pDMS	0.72 (0.70 – 0.73)	<0.05	—	—

All data are described as r (Pearson correlation coefficient), 95% CI

Table 4. Comparison chart of pediatric scoring tools

Previous Scoring tool	National children's hospital pediatric specific pharmacy scoring tool ¹⁶	CAMEO II scoring tool ¹⁷	PRISM III scoring tool ¹⁸
Description	Provides pediatric patient prioritization for pharmacist review reducing the need for chart searching	Nurse based scoring tool to quantify the acuity of pediatric ICU nursing utilized for staffing models	Evaluates the pediatric risk of mortality based on lab values from the first and second 12 hours of ICU stay
Comments	Does not specifically target ICU patients, does not include patient outcomes, focused on quantifying time spent on each patient by clinical pharmacist	Not used to prioritize pharmacist intervention based on medication complexity	Not used to prioritize pharmacist intervention based on medication complexity

two measures pDMS and MRC-ICU demonstrated high correlation (0.72 [CI 0.70 – 0.73]), $p < 0.05$.

Following logistic regression controlling for age, sex and weight every 1-point increase in MRC-ICU was associated with 1.26 increased in odds of mortality (1.26 [CI 1.19 – 1.32]), $p < 0.05$. Similarly, based on linear regression every 1-point increase in MRC-ICU was associated with 38.44 hours of additional hospital length of stay (38.44 [CI 34.28 – 42.60]), $p < 0.05$ as well as 14.40 hours of additional ICU length of stay (14.40 [CI 13.00 – 15.80]), $p < 0.05$.

Following logistic regression controlling for age, sex and weight every 1-point increase in pDMS was associated with 1.22 increased in odds of mortality (1.22 [CI 1.15 – 1.29]), $p < 0.05$. Every 1-point increase in pDMS was associated with 44.47 hours of additional hospital length of stay (44.47 [CI 39.21 – 49.73]), $p < 0.05$ as well as 14.40 hours of additional ICU length of stay (13.25 [CI 11.43 – 15.08]), $p < 0.05$. Complete results can be found summarized in Table 3.

Discussion

In the first evaluation of the MRC-ICU Scoring Tool in the pediatric ICU population, this measurement of medication regimen complexity demonstrated appropriate clinical validity. Similar to the original validation studies of the MRC-ICU in the adult population, MRC-ICU demonstrated convergent validity, as evidenced by significant correlation with number of medications and number of medication orders, while showing divergent validity by not relating to patient sex. From a clinical perspective, MRC-ICU showed significant correlation to patient-centered outcomes, including mortality and length of stay. Most interestingly, it also showed a relationship with an existing institutional metric intended to capture patient priority from the perspective of pharmacist workload.

Both the pDMS and MRC-ICU had similar goals in mind, with the concept of quantifying, in a reproducible manner, the types of medications that require

advanced clinical pharmacist expertise and time for appropriate assessment. For example, the pDMS captures how monitoring a patient on vancomycin or an aminoglycoside has multiple clinical aspects that the pharmacist must consider, including dose, renal function, other nephrotoxins, etc. Similar to the MRC-ICU, the pDMS accounts for these considerations with a weighted point system. For example, one point is awarded for any patient on vancomycin, one point for any patient with a Creatinine Clearance (CrCl) < 30 mL/min/m² and on vancomycin, and two points for any patient receiving vancomycin pulse dosing. If the patient meets the criteria, points are awarded and added together for a total acuity score. The higher the score, the more monitoring and time the pharmacist will need to dedicate to that patient during their review. The higher score also informs the pharmacist on the order in which they should review patients getting to the most critical first. The patient with CrCl < 30 mL/min/m² and on vancomycin (2 points) has the potential to require additional monitoring and is more complex compared to a patient on vancomycin with normal renal function (1 point).

Unlike other previous scoring tools, the modified MRC-ICU and pDMS tool focuses on the ICU patient population. Providing validation for the use of this tool in pediatric population may allow for more tailored use of the pediatric clinical pharmacist within the ICU. Table 4 describes popular pediatric scoring tools. The current pediatric ICU tools are used for staffing or risk stratification, but no tool focuses on pharmacist intervention equating to outcomes in the pediatric ICU setting. Pharmacist prioritization tools are available for the general pediatric ward but are not ICU specific and are only based on the amount of time a pharmacist spends with a patient.

This study is limited by its single-center, retrospective design which precludes robust evaluation of external validity as well as causative inferences. The present study did not include any adjustments

for severity of illness scores, which may confound interpretations of medication regimen complexity. Unlike the MRC scoring tool, there was no divergent validity for the patients age and weight. Developmental changes seen with aging in pediatric patients' effects both the pharmacokinetics and pharmacodynamics of drugs, therefore age, not just weight must be considered when determining drug therapy. The cause of the difference between these findings may warrant further exploration in the future.¹⁵ Finally, while both scores have demonstrated appropriate face validity (as evidenced by adoption for use), true correlations of how these scores relate to pharmacist workload (or how pharmacists potentially mitigate adverse events and outcomes) require assessment in a prospective study design. The results of this study demonstrating initial validity support future investigations that incorporate severity of illness and more robust workload measurement of pharmacists.

Conclusion

In the first analysis of two different objective scoring systems for critically ill pediatric patients, both scores demonstrated initial validity measured from multiple different perspectives (e.g., face, convergent, divergent, criterion). Next steps include prospective validation of the score by investigating relationship of these scores to accepted measures of pharmacist workload.

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References

1. Newsome AS, Murray B, Smith SE, et al. Optimization of critical care pharmacy clinical services: A gap analysis approach. *Am J Health Syst Pharm.* 2021;78(22):2077–2085. doi:10.1093/ajhp/zxab237
2. Sikora A, Ayyala D, Rech MA, et al. Impact of Pharmacists to Improve Patient Care in the Critically Ill: A Large Multicenter Analysis Using Meaningful Metrics With the Medication Regimen Complexity-ICU (MRC-ICU) Score. *Crit Care Med.* 2022;50(9):1318–1328. doi:10.1097/CCM.0000000000005585
3. Webb AJ, Rowe S, Newsome AS. A descriptive report of the rapid implementation of automated MRC-ICU calculations in the EMR of an academic medical center. *Am J Health Syst Pharm.* 2022;79(12):979–983. doi:10.1093/ajhp/zxac059
4. Newsome AS, Smith SE, Olney WJ, et al. Multicenter validation of a novel medication-regimen complexity scoring tool. *Am J Health Syst Pharm.* 2020;77(6):474–478. doi:10.1093/ajhp/zxz330
5. Newsome AS, Smith SE, Olney WJ, et al. Medication regimen complexity is associated with pharmacist interventions and drug-drug interactions: A use of the novel MRC-ICU scoring tool. *JACCP: JOURNAL OF THE AMERICAN COLLEGE OF CLINICAL PHARMACY.* 2020;3(1):47–56. doi:10.1002/jac5.1146
6. Olney WJ, Chase AM, Hannah SA, et al. Medication Regimen Complexity Score as an Indicator of Fluid Balance in Critically Ill Patients. *J Pharm Pract.* 2022;35(4):573–579. doi:10.1177/0897190021999792
7. Hawkins WA, Smith SE, Newsome AS, et al. Fluid Stewardship During Critical Illness: A Call to Action. *J Pharm Pract.* 2020;33(6):863–873. doi:10.1177/0897190019853979
8. Bissell BD, Laine ME, Thompson Bastin ML, et al. Impact of protocolized diuresis for de-resuscitation in the intensive care unit. *Crit Care.* 2020;24(1):70. doi:10.1186/s13054-020-2795-9
9. Hirsch JD, Metz KR, Hosokawa PW, et al. Validation of a patient-level medication regimen complexity index as a possible tool to identify patients for medication therapy management intervention. *Pharmacotherapy.* 2014;34(8):826–835. doi:10.1002/phar.1452
10. Gwynn ME, Poisson MO, Waller JL, et al. Development and validation of a medication regimen complexity scoring tool for critically ill patients. *Am J Health Syst Pharm.* 2019;76(Supplement_2):S34–S40. doi:10.1093/ajhp/zxy054
11. Rosenberg DI, Moss MM, Section on Critical Care, et al. Guidelines and Levels of Care for Pediatric Intensive Care Units. *Pediatrics.* 2004;114(4):1114–1125. doi:10.1542/peds.2004-1599
12. Smith HAB, Besunder JB, Betters KA, et al. 2022 Society of Critical Care Medicine Clinical Practice Guidelines on Prevention and Management of Pain, Agitation, Neuro-muscular Blockade, and Delirium in Critically Ill Pediatric Patients With Consideration of the ICU Environment and

- Early Mobility. *Pediatr Crit Care Med*. 2022;23(2):e74–e110. doi:10.1097/PCC.0000000000002873
13. AHFS Drug Information. AHFS Drug Information. Accessed October 9, 2023. <https://ahfsdruginformation.com/>
 14. Anatomical Therapeutic Chemical (ATC) Classification. Accessed October 9, 2023. <https://www.who.int/tools/atc-ddd-toolkit/atc-classification>
 15. van den Anker J, Reed MD, Allegaert K, et al. Developmental Changes in Pharmacokinetics and Pharmacodynamics. *J Clin Pharmacol*. 2018;58 Suppl 10:S10–S25. doi:10.1002/jcph.1284
 16. D Brax A, Sapko MM, Cole JW, et al. Implementation of an electronic pharmacy scoring tool to prioritize clinical pharmacists' daily workflow at a pediatric institution. *Am J Health Syst Pharm*. 2023;80(2):68–74. doi:10.1093/ajhp/zxac261
 17. Connor JA, LaGrasta C, Gauvreau K, et al. Scaling the Measurement of Pediatric Acuity Using the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO II) Tool. *Dimens Crit Care Nurs*. 2019;38(3):146–152. doi:10.1097/DCC.0000000000000356
 18. Gonçalves JP, Severo M, Rocha C, et al. Performance of PRISM III and PELOD-2 scores in a pediatric intensive care unit. *Eur J Pediatr*. 2015;174(10):1305–1310. doi:10.1007/s00431-015-2533-5