Complexity Assessment and Monitoring to Ensure Optimal Outcomes Tool for Measuring Pediatric Critical Care Nursing

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Background Historically, nursing productivity has been measured in adult settings and based on time, intensity, and resource allocation.
Objective To develop a comprehensive measure of pediatric critical care nursing workload.
Methods An expert panel of pediatric critical care nurses used a modified Delphi method to identify 14 domains of nursing care with a number of corresponding care items in each domain. By consensus, they assigned each care item a cognitive complexity rating from 1 to 5. The panel next developed a classification system (classes I-V) to support interpretation of the patient's total score. The Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool was initiated with a cohort of 75 pediatric cardiac critical care patients to verify comprehensive capture of nursing care. Results of completed CAMEO tools were summarized by using descriptive statistics.
Results The cognitive workload across 14 domains of care was described, and each care item in the domain was scored. The range of CAMEO total scores was 25 to 230 (median, 124). For the initial cohort of patients, the cognitive complexity of care classifications were 13% as class I or II, 80% as class III or IV, and 7% as class V.
Conclusions The CAMEO tool was comprehensive in describing and quantifying the cognitive workload of pediatric critical care nurses. The CAMEO classification process informs staffing needs that support synergy between the needs of patients and their families and nurses' knowledge and skill. Articulation of nursing care focused on informed clinical decision making is needed to justify the value of skilled nurses. (*American Journal of Critical Care.* 2015;24:000-000)

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Nursing productivity has been measured to describe and quantify nursing workload, intensity, and resource allocation.[1-18] These tools were mostly developed and tested in adult critical care settings in the 1970s and 1980s.[1-18] Pediatric critical care requires an additional knowledge base and skill set to care for patients with varying developmental constraints plus congenital or acquired pediatric disorders. The current tools for measuring nursing workload are not inclusive of these multiple dimensions of pediatric critical care nursing. Therefore, we developed the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool to address the cognitive workload of nursing care.

Review of Literature

In the past 40 years, researchers have attempted to measure nursing workload. An early tool linking nursing activities with patients' acuity was the Therapeutic Intervention Scoring System (TISS). In 1974, Cullen et al[1] developed the TISS to estimate the severity of illness of adult patients in the intensive care unit by quantifying nursing interventions, support activities, and resources used for care. The TISS was subsequently revised to illustrate that time required for direct nursing activities correlated with an increase in nursing workload and depicted an accurate means of measuring nursing workload.[2-5] One of the few efforts to adapt an existing workload tool to the pediatric critical care population was the modification of the TISS in the late 1970s. This modification was used to define use patterns, the relationship of severity of disease to survival, and the factors that determined patients' outcome. Results were similar to those of the original TISS: nursing interventions trending upward as patients' severity of illness trended upward.[19,20]

Current nursing workload tools do not include dimensions of pediatric critical care.

None of the current nursing workload tools measures cognitive complexity, that invisible process of decision making during nursing care. Cognitive workload, defined by Ebright and colleagues,[21] is the intellectual processing of information about patients that drives performance and decision making. Few researchers have focused on the cognitive aspect of clinical decision making related to patient/family-centered care.[22,23] Researchers have described the broad range of thinking processes required in the acute care setting but have not articulated the magnitude of cognitive processes and the quantification of cognitive workload complexity.[22-24] The purpose of this study was to describe and quantify the cognitive workload and complexity of contemporaneous pediatric critical care nursing.

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Study Setting

A single cardiac intensive care unit (CICU) in Boston Children's Hospital, a 395-bed, freestanding pediatric quaternary hospital, was the study site. The 29-bed CICU is dedicated to the management of infants, children, and adults with congenital or acquired heart disease. Patients are admitted either postoperatively from the cardiac operating room or for medical management of conditions such as cardiomyopathy, myocarditis, heart failure, and dysrhythmias. Many patients require support with multiple inotropic drugs to maintain hemodynamic stability or require mechanical assistance as a bridge to transplant. In addition, surgical procedures such as delayed sternal closure, chest exploration, and extracorporeal membrane oxygenation (ECMO) cardiopulmonary resuscitation are performed on the unit. The nurse to patient ratio is either 1 to 1 or 1 to 2, depending on patient care needs. Direct patient care is delivered solely by registered nurses. Nursing ancillary staff may assist in nursing procedures but are not independent care providers. Family-centered care is a key practice tenet, and patients' families are encouraged to be active team members.

Phase I

After approval was granted by the institutional review board, an expert panel of 8 cardiovascular intensive care nurses was convened and charged with reviewing existing nursing workload tools,

almost all of which were developed for use in adult ICUs.[8-10] This panel included experienced bedside nurses, a charge nurse, a clinical nurse specialist, and a clinical coordinator. A number of ICU tools were pilot tested, and none had a specificity of nursing care assessment, monitoring, and intervention that the panel deemed adequate. The tools also lacked description of care coordination, family support, and the indirect care management that is part of the bedside nursing role and is considered a component of cognitive workload.

Next the expert panel was charged to develop a list of all the interventions that represented their current practice. Using a modified Delphi technique, the expert panel participated in a series of 5 data query rounds.[25,26] Rounds I to III focused on content development for the tool. The panel was encouraged to subtract and add to the proposed content to achieve a comprehensive list of items representing direct and indirect clinical interventions and nursing.[27(pp10-18)] Using the Nursing Interventions Classification[28] language, the panel initially identified 19 domains of care to use for organizing their comprehensive list. Upon review, they noted redundancy, and after discussion, they reached consensus for 14 domains of care (Table 1).

The expert panel detailed how multiple cognitive processes were involved in the direct and indirect nursing interventions made throughout their shift. Clearly, nursing interventions are more than discrete entities. To capture the complexity of cognitive processes, line items corresponding to each intervention were identified. For example, if an order was written for intermittent intravenous furosemide, the nurse included as line items the critical thinking processes that accounted for giving the medication plus determining if the medication was the correct dose, the patient's vital signs were acceptable, and the patient's fluid balance and electrolyte values supported drug administration. By identifying all of these line items, a more complete representation of the cognitive processes involved in nursing assessment, intervention, and evaluation of a patient's status is demonstrated. Many higher level nursing skills in addition to the technical skills are involved in the administration of an intermittent intravenous medication.

In rounds IV and V, the expert panel was asked to rate each line item individually on a scale from 1 to 5 in terms of cognitive workload complexity. The rated items were then presented to the expert panel for review. Members engaged in discussion of ratings, coming to consensus where differences existed and providing a final confirmation of each item. Cognitive workload complexity was defined as the intellectual processing of information about patients that drives decision making and performance.[21] A cognitive complexity rating of 1 required the least cognitive thought process, whereas a rating of 5 required the most. For the monitoring domain, a complexity score was assigned on the basis of how often vital signs were recorded as well as the type of assessment: noninvasive or invasive.

Table 1
Domains of care in the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool

1. Monitoring
2. Intermittent medications
3. Vasoactive intravenous medications
4. Continuous intravenous medications
5. Respiratory
6. Resuscitation
7. Infection control
8. Nursing assessment, management, and intervention
9. Procedures and testing within the intensive care unit
10. Activities of daily living/self/assisted care
11. Transfers/admissions/transport
12. Assessment of anxiety/coping/mood/family adjustment
13. Inpatient coordination of care/ teaching/ anticipatory guidance to patient/family
14. Professional/environmental management

A similar process was used with the following domains: continuous intravenous medications, vasoactive intravenous medications, and the coordination of care and patient/family teaching. For example, the expert panel concluded that it was more important to assign a complexity score that was based on the total number of inotropic agents or continuous intravenous medications as opposed to weighting specific medications. The interventions within the coordination of care/teaching/anticipatory guidance to patient/family domain were deemed as ongoing throughout the patient's hospitalization. These interventions also demonstrated cognitive complexity in ongoing critical thinking and complex decision making and were best reflected by the number and coordination of ancillary services consulted throughout the nurse's shift.

The panel reached consensus for 14 domains of care.

Low complexity ratings (1-2) were given to activities such as standard infection control procedures and simple dressing changes. Frequent monitoring of vital signs (>15 minutes), airway maintenance, and procedures such as extubation and catheter insertions/removals were assigned a midlevel complexity rating (3). The most complex items (4-5) included activities such as laboratory data interpretation, ECMO-related activities, and

Table 2
Demographics and clinical characteristics of 75 patients in the study

Characteristic	No. (%) of patients
Age	
<1 month	30 (40)
<1 year	23 (31)
1 year-18 years	16 (21)
>18 years	6 (8)
Male sex	39 (52)
Race	
White	52 (69)
Nonwhite	23 (31)
Type of admission	
Medical	11 (15)
Surgical	65 (87)

resuscitation attempts. Description and quantification of the magnitude of nursing care was evident in the total score (phase II). To arrive at a total score, each of the care items with their associated number (1-5) would be summed across the 14 domains of care.

Phase II

Once consensus was reached on the care items and their cognitive workload complexity, phase II of the interpretation of cognitive workload began. The expert panel was charged with constructing classification categories for cognitive workload complexity that were based on total score. Five cognitive workload complexity classification groups (I-V) were identified. In class I, nursing assessment, monitoring, and management are focused on maintaining goal hemodynamics, and the coordination of care/teaching/anticipatory guidance is focused on a seamless transition to non–ICU-level nursing care. In contrast, patients in class V require frequent intensive care nursing assessment, monitoring, and management. Various interventions and procedures may be necessary to achieve and maintain goal hemodynamics. Coordination of care/teaching/anticipatory guidance requires medical/surgical team consultations as does patient/family teaching and support. The resulting tool and cognitive workload classification system was named Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO).

It is essential to detail the cognitive workload complexity required of critical care nurses.

To confirm the capture of the cognitive complexity of nursing care, the final version of the CAMEO tool was completed retrospectively in 75 patients admitted to the cardiac intensive care unit in a 1-month period. Each patient had been admitted for at least 24 hours at the time of review. The clinical lead from the investigative team abstracted data from the electronic medical record for each CAMEO. Descriptive statistics were used to summarize the cohort of patients (Table 2). Each CAMEO was then assessed for frequency of each line item (Table 3). The distribution of total scores for the 75 patients was then used to determine the cut points for the range of scores for final placement in 1 of the 5 CAMEO cognitive complexity classifications (I-V). The cognitive complexity workload for the 75 patients is represented by their classification (see Figure).

Results

Characteristics of Patients

Among the 75 patients, more than 70% of patients were less than 1 year of age, with 52% male and 69% reported as white (Table 2). Eighty-seven percent of patients were admitted for surgical recovery. The median length of CICU stay was 6.50 days (range, 1-207 days).

CAMEO Domains

Fourteen domains of nursing represented the cognitive workload of care delivery. Table 3 illustrates the domains and the list of line items. Table 4 provides the results from the 75 patients' charts that were reviewed to verify that all aspects of nursing care were captured in the CAMEO. This review did not result in addition of any items to the CAMEO.

CAMEO Complexity Classification

For the 75 patients whose charts were reviewed, the total scores ranged from 25 to 230 with a mean score of 120 and a median score of 124. CAMEO classification for the cohort of 75 was 13% in class I or II, 80% as class III or IV, and 7% as class V (see Figure).

Discussion

The CAMEO tool enables description and quantification of the cognitive workload of pediatric cardiovascular critical care nurses. The nursing process of care is aimed at assessing, synthesizing, planning, and intervening to address actual or potential human responses to health and illness.[29] This process has been described as nonlinear, involving complex reasoning and decision making.[30] While advances in medical and surgical treatments evolve in pediatric critical care so too must nurses' knowledge and skill expand to provide quality holistic care for patients and parents. Quantification of the complexity of the cognitive workload of the nursing process provides recognition that advanced knowledge and skills are requisite to ensure optimal outcomes for patients. It is essential to detail the cognitive workload complexity required of critical

Table 3
Percentages of the 75 patients receiving nursing care in the 14 domains of the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool

Domain and nursing care	No. (%) of patients receiving nursing care
1. Monitoring	
Fluid balance (including urine output, chest tubes, peritoneal dialysis, continuous venovenous hemofiltration, drains)	75 (100)
Noninvasive vital signs: heart rate, respiratory rate, noninvasive blood pressure, oxygen saturation, end-tidal carbon dioxide, near infrared spectroscopy, bispectral index, pupils, expiratory tidal volume, mean airway pressure (ventilator), temperature, loss of consciousness, pain	75 (100)
Invasive: central venous pressure, umbilical arterial and venous pressures, arterial blood pressure, intracardiac pressures, intracranial pressure, intra-abdominal pressure	61 (80)
Chest tubes/drains	46 (61)
Open chest	10 (13)
Assist device (ventricular assist device, catheter-based pump, oxygenator)	2 (3)
Extracorporeal membrane oxygenation	5 (7)
Pacer, temporary wires	23 (31)
Pacer/automatic implantable cardioverter defibrillator, permanent	2 (3)
Seizures	5 (6)
2. Intermittent medications (circle all that apply)	
Nasogastric, nasojejunal, gastric, jejunal, oral	49 (65)
Topical, otic, ophthalmic, rectal	42 (56)
Inhalation: metered-dose inhaler, nebulizer	17 (23)
Patient/nurse controlled analgesia	0 (0)
Injection: subcutaneous/intramuscular	5 (7)
Epidural/intrathecal	0 (0)
Standard intravenous medications	63 (84)
Fluid bolus	8 (11)
Chemotherapeutic agents	0 (0)
Blood products (including 5% albumin)	20 (27)
Intravenous immunoglobulin G	0 (0)
3. Vasoactive intravenous medications (circle the number that applies) 1 infusion; 2 infusions; 3 infusions; 4 infusions; >4 infusions	
Dopamine	47 (63)
Epinephrine	10 (13)
Esmolol	10 (13)
Milrinone	26 (35)
Nipride	12 (16)
Nitroglycerin	2 (3)
Norepinephrine	2 (3)
Phenylephrine	0 (0)
Vasopressin	0 (0)
Other(s):	2 (3)
4. Continuous intravenous medications (circle the number that applies) 1 infusion; 2 infusions; 3 infusions; 4 infusions; >4 infusions	
Calcium gluconate	2 (3)
Cisatracurium	0 (0)
Dexmedetomidine	12 (16)
Diltiazem	0 (0)
Fentanyl	62 (83)

Continued

Table 3
Continued

Domain and nursing care	No. (%) of patients receiving nursing care
4. Continuous intravenous medications (circle the number that applies) 1 infusion; 2 infusions; 3 infusions; 4 infusions; >4 infusions	
Furosemide	22 (29)
Heparin	34 (45)
Intralipids	10 (13)
Midazolam	12 (16)
Morphine	12 (16)
Prostaglandin E_1	0 (0)
Propofol	2 (3)
Triiodothyronine	0 (0)
Vecuronium	12 (16)
Procainamide	0 (0)
Others	10 (13)
5. Respiratory (circle all that apply)	
Supplemental oxygen (nasal cannula, high-flow nasal cannula, blowby)	14 (19)
Bilevel positive airway pressure, continuous positive airway pressure	2 (3)
Conventional ventilator management	51 (68)
High-frequency oscillatory ventilation, jet ventilation	0 (0)
Continuous nebulizer	0 (0)
Isoflurane/heliox/inhaled nitric oxide, etc	0 (0)
Lidocaine for suctioning	0 (0)
6. Resuscitation (circle if applicable)	
Resuscitation: cardiopulmonary resuscitation, defibrillation, cardioversion, emergency medicines	0 (0)
7. Infection control (circle if applicable)	
Enhanced precautions (contact, droplet, etc)	26 (39)
8. Nursing assessment, management, and intervention (circle all that apply)	
Administer procedural sedation	0 (0)
Neurological/seizure management	5 (7)
Epidural/intrathecal port management	0 (0)
External ventricular device/intracranial bolt management	0 (0)
Pain/sedation/narcotic withdrawal management	58 (77)
Airway/endotracheal tube maintenance	51 (68)
Ventilatory support weaning	39 (52)
Critical airway/fresh tracheostomy management	0 (0)
Tracheostomy care	0 (0)
Spit fistula care	0 (0)
Endotracheal tube/tracheostomy suctioning	46 (61)
Oral/nasopharyngeal/nasal suctioning	46 (61)
Cough assist vest	0 (0)
Chest physiotherapy	17 (23)
Arrhythmia management	8 (11)
Pacing wire removal	2 (3)

Continued

Table 3
Continued

Domain and nursing care	No. (%) of patients receiving nursing care
8. Nursing assessment, management, and intervention (circle all that apply)	
Blood product rapid infuser management	0 (0)
Postprocedural bleeding management	12 (16)
Temperature/fever regulation	26 (35)
Cooling/warming blanket	2 (3)
Gastrointestinal/feeding tube management	24 (32)
Gastrointestinal/feeding tube insertion/removal	2 (3)
Chest tube/Blake/Jackson-Pratt/peritoneal dialysis drain management	32 (43)
Gastrointestinal/ostomy tube care	0 (0)
Bladder scanner	0 (0)
Genitourinary (urinary catheter/ureteral) tube management	24 (32)
Urinary catheter insertion/removal/straight catheterization	8 (11)
Peritoneal dialysis	2 (3)
Sequential compression devices	8 (11)
Splints/orthotics	0 (0)
External traction	0 (0)
Wound care/dressing change; simple	32 (43)
Wound care/dressing change; complex	0 (0)
Vacuum-assisted wound management	0 (0)
Peripheral intravenous catheter site management	51 (68)
Peripheral intravenous catheter insertion/removal	10 (13)
Peripheral intravenous catheter tubing change/infusion change	29 (39)
Central venous/arterial/intracardiac/peripherally inserted catheter maintenance/indwelling port	61 (81)
Fluid balance	51 (68)
Drug mixture (intravenous)	8 (11)
Drug dose calculation	56 (75)
Point-of-care testing	17 (23)
Capillary/heel puncture	5 (7)
Noncannulated site (peripheral stick)	5 (7)
Arterial venous port	51 (68)
Specimen (cultures/laboratory samples) management	46 (61)
Laboratory data interpretation (acid/base balance, electrolytes, hematology)	53 (71)
End-of-life care/postmortem care	2 (3)
9. Procedures/testing within the intensive care unit (circle all that apply)	
Intubation	0 (0)
Extubation	8 (11)
Bronchoscopy	2 (3)
Cardioversion	0 (0)
Chest tube/drain placement	5 (7)
Chest tube/drain removal	0 (0)
Electrocardiography	14 (19)
Echocardiography	0 (0)
Extracorporeal membrane oxygenation: cannulation/decannulation/circuit change	2 (3)

Continued

Table 3
Continued

Domain and nursing care	No. (%) of patients receiving nursing care
9. Procedures/testing within the intensive care unit (circle all that apply)	
Balloon atrial septostomy	0 (0)
Chest exploration/opening/closure	2 (3)
Abdominal exploration	0 (0)
Vacuum-assisted wound dressing change	0 (0)
Vacuum-assisted wound dressing insertion	0 (0)
Computed tomography of head	0 (0)
Chest radiography	24 (32%)
Electroencephalography	0 (0)
Ultrasound (head, abdomen, etc)	8 (11)
Lumbar puncture	0 (0)
Central venous, intracardiac, arterial, umbilical, peripherally inserted catheter insertion	0 (0)
Central venous, intracardiac, arterial, umbilical, peripherally inserted catheter removal	10 (13)
Plasmapheresis	0 (0)
Hemofiltration	0 (0)
Continuous venovenous hemofiltration	2 (3)
10. Activities of daily living/self/assisted cares (circle all that apply)	
Oral feeding with assistance	8 (11)
Bottle feeding	2 (3)
Nasogastric, nasojejunal, gastric, jejunal feedings	26 (35)
Skin care, complex	34 (45)
Toileting	20 (27)
Ambulation with assistance	20 (27)
11. Transfers/admissions/transport (circle all that apply)	
Floor	10 (13)
Home	0 (0)
Operating room	12 (16)
Magnetic resonance imaging	0 (0)
Catheterization laboratory	5 (7)
Radiology (computed tomography, ultrasound, radiography)	0 (0)
Interventional radiology	0 (0)
Outside facility	0 (0)
Emergency department	0 (0)
Nuclear medicine	0 (0)
Other	0 (0)
12. Assessment of anxiety/coping/mood/family adjustment (circle if applicable)	
Noneffective	14 (19)
13. Inpatient coordination of care/teaching/anticipatory guidance to patient/family (circle the number that applies)	
Case management/consultant (social work, child life, resource specialist, psychology, physical/occupational therapy, lactation, interpreter services	12 (16)
Nutrition (calories per kilogram per day)	39 (52)
Admission/discharge	8 (11)

Continued

Table 3
Continued

Domain and nursing care	No. (%) of patients receiving nursing care
13. Inpatient coordination of care/teaching/anticipatory guidance to patient/family (circle the number that applies)	
Orientation to the unit/floor	0 (0)
Disease process	36 (48)
Medication	32 (43)
Procedure/treatment	22 (29)
Family presence facilitation	19 (25)
Postoperative education	29 (39)
Preoperative education	5 (7)
Multidisciplinary care meeting/family meeting	2 (3)
Organ donation	0 (0)
Other	0 (0)
14. Professional/environmental management (circle all that apply)	
Clinical practice guidelines/management plans	34 (45)
Delegation to unlicensed personnel	14 (19)
Documentation	75 (100)
Technology management	56 (75)
Incident reporting (Safety Event Reporting System)	0 (0)
Precept: employee	5 (7)
Precept: student	0 (0)
Research/quality data collection	36 (48)
Staff development (side by sides, resource)	5 (7)
Shift report, complex	73 (97)
Sitter	0 (0)
Security	0 (0)
Unit/institution meetings	0 (0)

care nurses, not only to continue the advancement of the nursing profession but also to provide guidance for educational innovations in theory and clinical skills necessary to care for such increasingly complex patients.

The CAMEO quantifies cognitive workload according to cognitive complexity and not time as associated with traditional methods of human factors engineering (HFE). HFE techniques have been useful in streamlining processes, increasing productivity, and decreasing costs while maintaining quality in health care. However, these processes tend to be control-based; for example, utilization of supplies or the observable direct care activities of medication delivery.[30,31] The limitations of HFE analyses are demonstrated when the work under measure is nonlinear, requires discretion, and is self-paced and unpredictable.[32] Nursing care is based on assessment of patients and response to the clinical situation. Dynamic in nature, it involves the intellectual processing of ongoing assessment, critical thinking, and clinical decision making including the ability to reprioritize on the basis of patients' changing status.

Measuring the cognitive workload captures the intellectual processing of information and decision making that defines nursing practice but is underestimated when measuring nursing workload in minutes and frequency of completing nursing tasks.[22,30] Research has shown that nurses' cognitive activity concerning patients is ongoing and may actually be most concentrated away from the bedside.[22,30] In fact, a significant difference was found between the amount of time spent in a particular location versus the cognitive focus on a particular patient.[22,30] Researchers have concluded that the intense but invisible activity of continually processing nursing

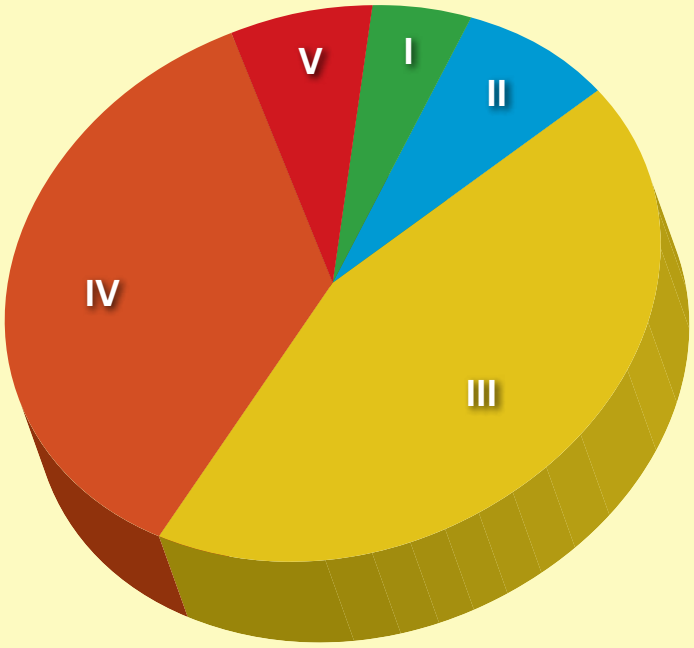

Figure Distribution of 75 patients by Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) classification.

care may be one reason why time and frequency of task used to guide nursing assignments and staffing ratios remain unsatisfactory.[22,30]

The 14 domains of the CAMEO describe not only the direct and but also the indirect cognitive processes associated with nursing care. The current pediatric health care environment characterized by increasing patient acuity, complex technology, and regulatory requirements has increased nursing responsibility and accountability. During the process of identifying domains of care, the expert panel agreed that 14 domains were needed in order to encompass the cognitive workload complexity and magnitude of daily, expected care practices. For several domains, the cognitive workload complexity related to the number of similar activities the nurse managed simultaneously as volume contributed more to complexity than did the particular characteristics of any 1 item. It is this cognitive stacking as described by Ebright and colleagues[21] that truly reflects the dynamic nature of nursing. The cognitive pathway of today's nurse is complex and nonlinear. Nurses are frequently challenged with multiple tasks that need to occur simultaneously because of the patient's symptoms and status. The ability to prioritize and reorganize care on the basis of knowledge and understanding of potential outcomes is essential.

Particularly important to the expert panel was developing the domain of professional and environmental management to include the numerous indirect responsibilities linked to the cognitive workload of nursing care. For example, serving as a preceptor for new staff entails teaching, guiding, critiquing, and supporting, all of which are done while also providing patient care. Although serving as a preceptor is an important professional responsibility, it definitely increases the level of cognitive workload while providing patient care.

The assignment of a cognitive workload complexity rating (1-5) for each line item illustrates the cognitive stacking of nursing care and how that contributes to the final CAMEO classification system. The expert panel was able to distinguish a difference in cognitive workload complexity, allowing for a distribution of line items on a scale of 1 to 5 with most line items considered a 1, 2, or 3 and a limited number of items rated as 4 or 5. However, it was the magnitude of all the line items that provided a final classification of cognitive workload complexity. In the cohort of 75 patients, most patients were classified as III or IV, which is reflective of nursing care required to support the hemodynamic status of patients, coordinate care, and manage the information needs of the patient's family.

A number of productivity tools measured frequency of care and time spent delivering care as a proxy for patient acuity to inform staffing and resource use.[1,4,6,9] Although these tools have some value in determining staffing needs, the expert panel did not find them adequate as they did not address the extensive, ongoing cognitive activity that constituted every nurse's practice. Also relevant and missing in these tools were ways in which the environment contributed to the cognitive complexity of care. The depth of knowledge and management of resources required for delivery of safe, effective, efficient care demands an ever-increasing amount of nursing work.

Moving toward a model of nursing care that is patient and family centered supports the demonstration of optimal outcomes.[33] The comprehensive lens of the CAMEO enables needs of patients (and their families) to be clearly delineated so that those needs can be matched with a nurse's skill set as conceptually described in the American Association of Critical-Care Nurses' Synergy Model for Patient Care.[33] Creating a nursing tool to illustrate the cognitive complexity of the work that critical care nurses perform provides a more comprehensive narrative of nursing practice and details nurses' vital role to key stakeholders in health care policy at the organizational level and beyond.

Limitations

The development and pilot testing of the CAMEO tool was conducted in 1 pediatric cardiac intensive care unit. Any statements of external generalizability require further multisite testing, which will be a focus for future study.

Table 4
Results of retrospective chart review

Domain	Summary of care items from retrospective review of 75 charts
Monitoring	Standard intensive care with noninvasive monitoring was reported in 100% of the patients, with invasive monitoring present in 81%. The rating of cognitive complexity for the care items of fluid balance, noninvasive monitoring, and invasive monitoring was based on frequency of assessment. Additional monitoring items included chest tubes/drains, open chest, ventricular assist devices, extracorporeal membrane oxygenation, pacing wires/pacemaker, and seizure monitoring. The range of cognitive complexity for each item was 2 to 5 points.
Intermittent medications	Most frequent were standard intravenous medications (84%), nasogastric/gastric tube medications (65%), topical medications (56%), and administration of blood products (26%). The cognitive complexity for these items ranged from 1 to 4.
Vasoactive intravenous medications	Most frequent vasoactive infusions were dopamine (62%) and milrinone (35%). Cognitive complexity based on number managed but could not exceed 5.
Continuous intravenous medications	The most frequently managed infusions were fentanyl (83%), heparin (45%), and furosemide (29%). Cognitive complexity based on number managed but could not exceed 5.
Respiratory	A number of different strategies could be used to support the patient's respiratory status. Most frequent was conventional ventilation (68%) with cognitive complexity range of 1 point to 5 points per item.
Resuscitation	Three components: compressions, defibrillation, and medications. Use of any of the 3 components equaled a cognitive complexity rate of 5.
Infection control	Infection control precautions were a frequent necessity in the intensive care environment; enhanced precautions required in 39% of patients.
Nursing assessment, management, and intervention	Each care item was considered nurse initiated. Of the 48 items, 12 (pain, sedation, narcotic withdrawal management, airway/endotracheal tube management, central catheter management) were present ≥ 50%. Cognitive complexity for items ranged from 1 to 5; 19 care items were a 2 and 14 care items were a 3.
Procedures and testing within the intensive care unit	Most common of the 25 items were chest radiograph (32%), electrocardiogram (19%), and central/arterial catheter removal (13%). Cognitive complexity ranged from 1 to 5; 9 care items were a 4 or 5.
Activities of daily living/self/assisted care	Feeding nasogastric tube/oral (48%), skin care (45%), and ambulation (26%) were most common. The cognitive complexity for each item was rated as a 1 or 2.
Transfers/admissions/transport	Most common of the 11 distinct items were transfer to the operating room (16%), patient acute care area (13%), and catheterization laboratory (6%). The cognitive complexity was similar being either 3 or 4.
Assessment of anxiety/coping/mood/family adjustment	Coping defined as effective coping requiring usual nursing support or noneffective coping requiring intensive support of the nurse and/or the extended health care team and cognitive complexity rate of 2.
Inpatient coordination of care/teaching/anticipatory guidance to patient/family	Most common items were teaching about the disease process (48%), medications (42%), and postoperative care (39%). Depending on the number of items addressed, cognitive complexity can range from 1 to a maximum of 15.
Professional/environmental management	These items represented the cognitive complexity beyond direct patient care but linked to patient support and the growth and support of the profession or environment. Cognitive complexity of each item ranges from 1 to 4 with the assumption that multiple items could occur within the nursing shift.

Use of the modified Delphi approach to develop the CAMEO tool was necessary to create the description and quantification of cognitive complexity. This method has been used previously; however, it is noted that there is bias in subjectivity.[25] Empirical testing of the CAMEO will be necessary to support future validation of the tool. Although retrospective assessment is also noted to have numerous limitations, the approach has been considered valid in tool development.[34] The length of the CAMEO in terms of line items may also be considered a limitation. Work is underway to streamline the CAMEO and focus on items beyond basic intensive nursing care that significantly contribute to classifying the complexity of nursing care.

Conclusions

The CAMEO tool was comprehensive in describing and quantifying the complexity of cognitive workload practiced by pediatric cardiovascular

critical care nurses. The use of CAMEO informs staffing needs through cognitive workload, allowing synergy among the needs of patients and their families and the knowledge and skills of nurses. Understanding nursing care beyond frequency and time required for "tasks" is necessary to fully inform the dialogue about professional practice models, nurse staffing decisions, and allocation of resources to best serve patients and their families.

Next Steps

Further adaptation of the CAMEO to qualify and quantify nursing care has begun in the medical-surgical and neonatal intensive care units, with the goal of having 1 tool. Empirical study will be conducted to support validation and use of the CAMEO beyond a single institution. The CAMEO will also move from a paper tool to an electronic document to inform real-time use of nursing resources and benchmarking.

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REFERENCES

1. Cullen DJ, Civetta JM, Briggs BA, Ferrara LC. Therapeutic intervention scoring system: a method for quantitative comparison of patient care. *Crit Care Med.* 1974;2(2):57-60.
2. Cullen DJ, Keene R, Waternaux C, Peterson H. Objective, quantitative measurement of severity of illness in critically ill patients. *Crit Care Med.* 1984;12(3):155-160.
3. Cullen DJ, Nemeskal AR, Zaslavsky AM. Intermediate TISS: a new Therapeutic Intervention Scoring System for non-ICU patients. *Crit Care Med.* 1994;22(9):1406-1411.
4. Iapichino G, Radrizzani D, Bertolini G, et al. Daily classification of the level of care. A method to describe clinical course of illness, use of resources and quality of intensive care assistance. *Intensive Care Med.* 2001;27(1):131-136.
5. Keene AR, Cullen DJ. Therapeutic Intervention Scoring System: update 1983. *Crit Care Med.* 1983;11(1):1-3.
6. Miranda DR. Management of resources in intensive care. *Intensive Care Med.* 1991;17(2):127-128.
7. Miranda DR. Scoring systems in the measurement of performance of ICUs. *Intensive Care Med.* 1999;25(4):418-419.
8. Miranda DR, de Rijk A, Schaufeli W. Simplified Therapeutic Intervention Scoring System: the TISS-28 items—results from a multicenter study. *Crit Care Med.* 1996;24(1):64-73.
9. Miranda DR, Moreno R, Iapichino G. Nine equivalents of nursing manpower use score (NEMS). *Intensive Care Med.* 1997;23(7):760-765.
10. Miranda DR, Nap R, de Rijk A, Schaufeli W, Iapichino G. Nursing activities score. *Crit Care Med.* 2003;31(2):374-382.
11. Bhadoria P, Bhagwat A. severity scoring system in pediatric intensive care units. *Indian J Anaesth.* 2008;52(6):663-675.
12. Liu L, Lee S, Chia PF, Chi SC, Yin YC. Exploring the association between nurse workload and nurse-sensitive patient safety outcome indicators. *J Nurs Res.* 2012;20(4):300-309.
13. Kirby E, Hurst K. Using a complex audit tool to measure workload, staffing and quality in district nursing. *Br J Community Nurs.* 2014;19(5):219-223.
14. Myny D, De Bacquer, D, Van Hecke A, et al. Validation of standard times and influencing factors during the development of the workload indicator for nursing. *J Adv Nurs.* 2013;70(3):674-686.
15. Camuci M, Martins J, Cardli A, et al. Nursing activities score: nursing workload in a burns intensive care unit. *Rev Latino-Am Enfermang.* 2014;22(2):325-331.
16. Dyksta C, Bridges E. Quantifying workloads and balancing assignments. *Nurs Manage.* 2012;43(10):36-42.
17. McDonough K. Development of the McDonough optimum staffing method: evidence-driven recommendations based on patient demand. *Nurses Today.* 2013;21(2):8-11.
18. Perroca M. The new version of a patient classification instrument: assessment of psychometric properties. *J Adv Nurs.* 2012;69(8):1862-1868.
19. Rothstein P, Johnson P. Pediatric intensive care: factors that influence outcome. *Crit Care Med.* 1982;10(1):34-37.
20. Trope R, Vaz S, Zinger M, Sagy M. An updated therapeutic intervention scoring system for critically ill children enables nursing workload assessment with insight into potential untoward events. [published online January 23, 2014]. *J Intensive Care Med.*
21. Ebright P, Patterson E, Chalko B, Render M. Understanding the complexity of registered nurse work in acute care settings. *JONA.* 2003;33(12):630-638.
22. Potter P, Wolf L, Boxerman S, et al. Understanding the cognitive work of nursing in the acute care environment. *JONA.* 2005;35(7/8):327-335.
23. Cornell P, Riordan M, Townsend-Gervis M. Barriers to critical thinking workflow interruptions and task switching among nurses. *JONA.* 2011;41(1):407-414.
24. Higuchi K, Donald J. Thinking processes used by nurses in clinical decision making. *J Nurs Educ.* 2002;41(4):145-153.
25. Proctor S, Hunt M. Using the Delphi survey technique to develop a professional definition of nursing for analysing nursing workload. *J Adv Nurs.* 1994;19:1003-1014.
26. Hsu C, Sanford B. The Delphi technique: making sense of consensus. *Pract Assess Res Eval.* 2007;12(10):1-8.
27. Bell L. *AACN Scope and Standards for Acute and Critical Care Nursing Practice.* Aliso Viejo, CA: American Association of Critical-Care Nurses; 2008.
28. Bulechek G, Butcher H, Dochterman J. *Nursing Interventions Classification (NIC).* 5th ed. St Louis, MO: Mosby Elsevier; 2008.
29. American Nurses Association. *Nursing's Social Policy Statement.* Silver Springs, MD: American Nurses Association; 1995.
30. Potter P, Boxerman S, Wolf L, et al. Mapping the nursing process: a new approach for understanding the work of nursing. *JONA.* 2004;34(2):101-109.
31. Gosbee J. Human factors engineering and patient safety. *Qual Saf Health Care.* 2002;1(4):352-354.
32. Pepitone J. A case for humaneering. *IIE Solutions.* 2002; 34(5):39-44.
33. Curley MAQ. *Synergy: The Unique Relationship Between Nurses and Patients.* Indianapolis, IN: Sigma Theta Tau; 2007.
34. Kontio E, Airola A, Pahikkala T, et al. Predicting patient acuity from electronic patient records. *J Biomed Inform.* 2014;51:35-40.