Pediatric Critical Care Resource Use by Children with Medical Complexity

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Objectives To examine the proportionate use of critical care resources among children of differing medical complexity admitted to pediatric intensive care units (ICUs) in tertiary-care children's hospitals.

Study design This is a retrospective, cross-sectional study of all children (<19 years of age) admitted to a pediatric ICU between January 1, 2012, and December 31, 2013, in the Pediatric Health Information Systems database. Using the Pediatric Medical Complexity Algorithm, we assigned patients to 1 of 3 categories: no chronic disease, noncomplex chronic disease (NC-CD), or complex chronic disease (C-CD). Baseline demographics, hospital costs, and critical care resource use were stratified by these groups and summarized.

Results Of 136 133 children with pediatric ICU admissions, 53.0% were categorized as having C-CD. At the individual-encounter level, ICU resource use was greatest among patients with C-CD compared with children with NC-CD and no chronic disease. At the hospital level, patients with C-CD accounted for more than 75% of all examined ICU resources, including ventilation days, ICU costs, extracorporeal membrane oxygenation runs, and arterial and central venous catheters. Children with a progressive condition accounted for one-half of all ICU resources. In contrast, patients with no chronic disease and NC-CD accounted for less than one-quarter of all ICU therapies.

Conclusion Children with medical complexity disproportionately use the majority of ICU resources in children's hospitals. Efforts to improve quality and provide cost-effective care should focus on this population. *(J Pediatr 2016;177:197-203).*

Children with medical complexity are a growing portion of hospitalized patients.[1] Although these children account for 10%-17% of pediatric hospital admissions, they account for a larger proportion of total hospital days and inpatient hospital charges.[2-5] Furthermore, they now comprise more than one-half of all admissions to the pediatric intensive care unit (ICU) and have greater risk of multiorgan dysfunction, prolonged length of stay, and mortality after admission to an ICU.[6,7] Previous studies have demonstrated a greater patient-level use of arterial and central venous catheters, mechanical ventilation, and length of stay in the ICU for children with medical complexity.[6,8,9] The overall proportionate distribution of ICU resources among children with and without medical complexity, however, is unclear and has not been delineated previously.

Because the proportionate distribution of resources in the ICU is unclear, describing the distribution of critical care resources, stratified by medical complexity, is an important first step in optimizing critical care use among all patient groups. To accomplish this, we stratified children in a cross-sectional pediatric inpatient dataset using the Pediatric Medical Complexity Algorithm (PMCA) and examined the overall proportionate use of critical care resources among children of varying medical complexity.

Methods

This is a retrospective, cross-sectional study in which we used the Pediatric Health Information System (PHIS) database. PHIS is a de-identified administrative dataset maintained by the Children's Hospital Association (Overland Park, Kansas) and includes administrative and billing data on inpatient, emergency department, ambulatory surgery, and observation discharges from more than 40 tertiary-care children's hospitals. The data warehouse function for PHIS is managed by Truven Health Analytics (Ann Arbor, Michigan), and several validity and reliability checks are performed before new data are incorporated into the PHIS database. We used all PHIS hospitalization data for

C-CD	Complex chronic disease
ECMO	Extracorporeal membrane oxygenation
ICU	Intensive care unit
Malignancy+	Malignancy with an additional chronic condition
NC-CD	Noncomplex chronic disease
NCD	No chronic disease
PHIS	Pediatric Health Information System
PMCA	Pediatric Medical Complexity Algorithm

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all children (<19 years of age) admitted to a pediatric ICU or pediatric cardiac ICU between January 1, 2012, and December 31, 2013, at 1 of 42 children's hospitals with complete clinical and billing data. We limited the analysis to the 2 most recent available years for a current appraisal of ICU resource use and to limit the impact of multiple encounters. Critical care, defined as admission to a pediatric ICU or a pediatric cardiac ICU, was identified in PHIS by the use of clinical transaction classification, a proprietary system used to categorize hospital billing services. This study was exempted from human subject research by the Institutional Review Board at Seattle Children's Hospital.

Classification of Medical Complexity

Using the PMCA, we assigned patients to 1 of 3 mutually exclusive categories for the study period: no chronic disease (NCD), noncomplex chronic disease (NC-CD), and complex chronic disease (C-CD).[10] The PMCA uses *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis codes to categorize pediatric medical complexity with good-to-excellent sensitivity (NCD: 96%; NC-CD: 41%; C-CD: 84%) and specificity (NCD:90%; NC-CD: 92%; C-CD: 92%). Unlike other tools for designating medical complexity, the PMCA is a nonproprietary, validated algorithm that stratifies patients into increasing levels of complexity for chronic illnesses and uses multiple health care encounters to assign a medical complexity category. Children with NC-CD have a chronic condition that is not progressive and may be episodic, such as asthma. Children with C-CD are those with either chronic conditions in ≥2 organ systems (eg, static encephalopathy and chronic pulmonary conditions), a progressive condition associated with decreased life expectancy (eg, muscular dystrophy), malignancy, or continuous technology dependence (eg, dialysis or tracheostomy).

PMCA optimally functions with up to 3 years of data to assign a patient's medical complexity.[10] For this reason, we used all PHIS hospitalization data from the entire calendar year of the first pediatric ICU admission (including subsequent hospitalizations after the first ICU admission) in addition to hospitalization data from the 2 previous calendar years, if available, to assign a medical complexity category. Patients with C-CD were further categorized by the type of chronic disease and number of affected organ systems (C-CD subcategories). Patients with a malignancy were categorized as malignancy, and malignancy with an additional chronic condition (malignancy+). Patients with a progressive condition (including patients with additional chronic conditions) were categorized as having progressive disease. Patients who were classified as C-CD as the result of chronic, nonprogressive disease in ≥2 organ systems were categorized as having 2-3 or ≥4 affected organ systems. For conditions that affect more than 1 organ system (eg, cystic fibrosis with pulmonary and endocrine disease), PMCA classifies only the primary affected organ system.

Statistical Analyses

All hospitalization encounters in which patients were admitted to a pediatric ICU or pediatric cardiac ICU were analyzed with the encounter as the unit of analysis. For patients who had multiple transfers to the ICU during the same hospitalization, critical care resources were aggregated over the entire encounter. Baseline demographics at the first ICU encounter were stratified by medical complexity. Race/ethnicity data were combined and categorized as non-Hispanic white, non-Hispanic black, Hispanic, and "other," which includes 7.3% of patients who are nonwhite and nonblack with missing ethnicity data. Insurance payer was dichotomized as governmental insurance vs nongovernment insurance. Differences in categorical variables were assessed for statistical significance with the χ^2 test for association; the Kruskal-Wallis test was used to assess differences in continuous variables.

Using All Patient Refined Diagnosis Related Groups (3M Health Information Systems, St. Paul, Minnesota), we categorized discharge diagnoses by using major diagnostic categories, with several major diagnostic categories grouped into larger, clinically related groups to simplify the number of diagnostic groups. Using All Patient Refined Diagnosis Related Groups, we classified encounters as primarily "medical" or "procedural." In addition, to differentiate between emergency procedures and planned ICU admissions associated with a planned procedure, primary procedure codes were grouped into planned or unplanned procedures, as classified by Berry et al.[11]

Critical care resource use in the ICU was analyzed by PMCA category and by C-CD subcategories. For each hospital day, patients who received a pediatric ICU room and nursing charge were considered to be admitted to the ICU on that specific day. Because room charges are assigned at a midnight census, the day after an ICU room charge also was considered ICU use. Therapies that were administered on days in which the patient was not admitted to the pediatric ICU (such as patients receiving mechanical ventilation via a tracheostomy on the ward or receiving vasoactive infusions in another unit) were excluded. Invasive mechanical ventilation days (not including noninvasive positive pressure ventilation because this may be a baseline therapy for some patients) and extracorporeal membrane oxygenation (ECMO) runs were identified with the use of clinical service and supply codes for mechanical ventilation and ECMO, respectively. Arterial and central venous catheters were identified by the use of supply and clinical service codes for catheter insertion or pressure monitoring (**Table I**; available at www.jpeds.com). Administration of vasoactive infusions (**Table I**) was identified from pharmacy billing codes for each infusion.

The proportion of ICU encounters in which patients received mechanical ventilation, ECMO, arterial and central venous catheters, and vasoactive infusions were included as measures of ICU resources, and differences across PMCA categories were assessed. Furthermore, ICU days, hospital days, and post-ICU days, along with duration of mechanical ventilation and number of vasoactive infusions received during the entire encounter, among patients receiving those therapies, were summarized with the median and IQR and analyzed for statistical differences. Hospital costs were analyzed across PMCA groups. Billed hospital charges were converted to costs by the use of hospital, year, and service-specific ratios