Epidemiology of Pediatric Critical Care Admissions in United States Children's Hospitals, 2014-2019

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Funding: None

Reprints: None requested

Word Count: 2915 (abstract 246/300, manuscript body 2669/2700)

Key Words: intensive care units, pediatric; epidemiology; resource allocation; hospital costs

Article Tweet: Children in the US have >140 PICU encounters per year per 100,000 children; disproportionately among children from disadvantaged neighborhoods. 13.8% of pediatric hospital encounters involve PICU services.

This is the author's manuscript of the article published in final edited form as:

Heneghan, J. A., Rogerson, C., Goodman, D. M., Hall, M., Kohne, J. G., & Kane, J. M. (2022). Epidemiology of Pediatric Critical Care Admissions in 43 United States Children's Hospitals, 2014-2019. Pediatric Critical Care Medicine: A Journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies, 23(7), 484–492. https://doi.org/10.1097/PCC.0000000000002956

Research in Context:

- 2019 data suggest that there are 5000+ PICU beds in United States hospitals.
- However, PICU utilization, including temporal trends, as relates to overall hospital utilization in the United States over time has not recently been described.
- Understanding how PICU beds are used is an important step in ensuring appropriate resource allocation and planning for the future of pediatric healthcare.

At the Bedside:

- PICU admissions in the United States are increasing over time, and admitted patients tend to be more complex.
- Many invasive procedures in the PICU are decreasing.
- This increase in admissions has not been accompanied by an increase in standardized costs for PICU care or PICU mortality.

Abstract:

Objective: To identify trends in the population of patients in pediatric intensive care units (PICU) over time.

Design: Cross-sectional, retrospective cohort study using the Pediatric Health Information System database.

Setting: 43 United States children's hospitals.

Patients: All patients admitted to PHIS-participating hospitals from January 2014 to December 2019. Individuals >65 years of age and normal newborns were excluded.

Interventions: None.

Measurements and Main Results: PICU care occurred in 13.8% of all pediatric hospital encounters and increased over the study period from 13.3% to 14.3%. Resource intensity, based on average H-RISK score, increased significantly across epochs (6.5 in 2014-2015 vs 6.9 in 2018-2019, $p<0.001$), although this was not consistently manifested as additional procedural exposure. The two most common disease categories in PICU patients were respiratory failure and cardiac and circulatory congenital anomalies. Of all PICU encounters, 35.5% involved mechanical ventilation, and 25.9% involved vasoactive infusions. Hospital-level variation in the percentage of days spent in the PICU ranged from 15.1% to 63.5% across the participating sites. Of the total hospital costs for patients admitted to the PICU, 41.7% of costs were accrued during the patients' PICU stay.

Conclusions: The proportional use of PICU beds is increasing over time, although was variable across centers. Case-based resource use and complexity of pediatric patients are also increasing. Despite the higher use of PICU resources, the standardized costs of PICU care per patient encounter have remained static. These data may help to inform current PICU resource allocation and future PICU capacity planning.

Introduction:

Hospitalized children may require admission to pediatric critical care units (PICUs) based on physiologic derangements, therapeutic interventions, need for intensive nursing care, or procedural support. The structure of PICUs, including nurse and physician staffing and unit capacity in the United States, has been previously described (1-6). Between 1995 and 2000, there was a 13.7% growth in the number of PICU beds in the United States, outpacing the total growth of the general pediatric population (1). Survey data from 2003 and 2004 estimated that there were about 350 PICUs in the United States, though over half of them were smaller units with fewer than eight beds (3). Most recently, data from the 2019 American Hospital Association survey suggest that there are approximately 5115 general medical/surgical PICU beds in US hospitals (6), however when dedicated pediatric cardiac intensive care unit and intermediate care unit beds are included, the number may be as high as 5908 (3).

International consensus guidelines outlining admission and discharge criteria for infants and children requiring the services of an intensive care unit have been developed (7). However, individual hospitals may have different criteria and guidelines for determining which patients are admitted or transferred to the PICU. While the absolute number of PICU beds has been described, the recent epidemiologic and financial characteristics of modern PICU clinical encounters have not. Understanding how these PICU beds are used is an important step in ensuring appropriate resource allocation and planning for the future of pediatric healthcare. This study aims to describe the current epidemiology of a cohort of PICU admissions in the United States from 2014-2019 (to exclude the impact of the COVID-19 pandemic in 2020 and 2021), including demographic, clinical, financial, and outcome data, and to examine national trends using a large administrative data set.

Materials and Methods: This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cross-sectional studies (Supplemental Digital Content). This study was deemed non-human subjects research by the University of Minnesota (Study #14488).

Data source. This is a cross-sectional, retrospective cohort study of encounters at Pediatric Health Information System (PHIS; Children's Hospital Association, Lenexa, Kansas) participant hospitals in the United States from January 1, 2014 to December 31, 2019. PHIS is an administrative and billing database that collects demographics, *International Classification of Diseases* diagnoses and procedures, and daily billing information from 49 tertiary children's hospitals. We excluded hospitals that did not consistently participate in PHIS during the study period and hospitals with poor data quality, resulting in 43 hospitals being included.

Patient inclusion and PICU identification. We included inpatient and observation encounters given the wide variability in how these distinctions are drawn in pediatric medicine (8). We excluded patients over the age of 65 years and normal newborns to better represent the core pool of potential PICU patients at children's hospitals. Admission to a PICU was defined as admission to any intensive care unit in the participating pediatric hospitals (including subspecialty PICU such as a cardiac intensive care or neurosurgery intensive care), excluding neonatal intensive care units, at any point during a patient's hospitalization.

Data abstraction. For included patients, we abstracted demographic (age, gender, race/ethnicity, payor, census region, household income, Child Opportunity Index [a neighborhood-level multi-indicator measure of resources which support positive child development, including high school graduation rate, proximity to health care services, access to healthy foods, etc (9)]), clinical

(diagnoses [grouped with the Agency for Healthcare Research and Quality Clinical Classification Software (10)], mechanical ventilation, procedural exposures, medication utilization), and outcome (PICU and hospital length of stay [LOS], mortality, cost, hospital and PICU readmission) data. In PHIS, costs are estimated from charges using hospital- and year-specific cost-to-charge ratios. Costs represent costs to the hospital, not to the patient or payors. Costs were inflated to 2019 dollars using the medical component of the Consumer Price Index. Examined hospital characteristics included the presence of an Accreditation Council for Graduate Medical Education-accredited pediatric critical care medicine fellowship training program, assessed using the American Medical Association FREIDA™ database (accessed June 22, 2021). Hospitalization Resource Intensity Scores for Kids (H-RISK), a relative cost weight assigned to each encounter based on the All Patient Refined Diagnosis Relational Group (APR-DRG) and level of severity (3M Corporation), was calculated to assess case-mix index. (11). H-RISK is a validated risk adjustment measure that accounts for severity differences across pediatric populations. The H-RISK is a resource intensity weight derived from the Healthcare Cost and Utilization Project Kids' Inpatient Database 2016 database of all pediatric hospitalizations. The weight for a particular APR-DRG and severity level is calculated as the mean cost all patients in this group divided by the mean cost of all hospitalized patients.

Analysis. Demographic and clinical characteristics were summarized with frequencies and percentages for categorical variables and geometric means and geometric standard deviations (GSD) for continuous variables. Geometric means were chosen due to the expected presence of asymmetric data and their utility in comparing changes in rates over time. Comparisons were made across two-year epochs (2014-2015, 2016-2017, and 2018-2019) using Wilcoxon rank sum tests (for continuous variables) and chi-square tests (for categorical variables). All analyses were

performed using SAS v. 9.4 (SAS Institute, Cary, North Carolina), and p-values < 0.05 were considered statistically significant.

Results:

Encounter-Level Data

4,525,527 distinct hospital encounters were recorded over the six year study period, of which 623,511 encounters (13.8%) involved care in the PICU. Demographic and clinical characteristics of the study population are shown in Table 1. More than half (53.5%) of PICU encounters were for patients under five years of age. Less than half (44.8%) of PICU encounters were female, and the majority (56.3%) had government-issued insurance. Children from neighborhoods with high social needs (as represented by Low or Very Low Child Opportunity Index values) comprised 43.4% of PICU admissions, compared to 40% of the population. Severity of illness, as measured by the H-RISK score, increased across each of the epochs, from 6.5 to 6.9 ($p<0.001$). 16,548 (2.7%) children who were admitted to the PICU died in the hospital during the study, of which 14,767 (89.2%) deaths occurred in the PICU (2.4% PICU mortality rate). The PICU mortality rate was stable across the epochs. Changes in demographic characteristics over the study time period can be found in Supplemental Digital Content 1.

The most common primary diagnosis groupings for PICU admissions across all three epochs were respiratory failure and cardiac or circulatory congenital anomalies, combining for approximately one-fifth of admissions. In each epoch, five of the ten most common primary diagnoses overlapped between PICU and non-PICU encounters. Primary encounter diagnoses over time for PICU encounters are found in Table 2.

The geometric mean of PICU length of stay was 2.7 days (GSD 2.8 days) and stable across the studied time period. More than one-third (35.5%) of PICU encounters involved mechanical ventilation, 25.9% vasoactive infusions, 1.8% renal replacement therapy, and 1.3% extracorporeal membrane oxygenation (Table 3). Non-invasive ventilation increased over each of the study epochs, but invasive mechanical ventilation did not show a similar decline. Use of renal replacement therapy decreased significantly over time ($p<0.001$). The use of central venous access, including both central venous catheters and peripherally-inserted central catheters (PICC lines), decreased significantly over time ($p<0.001$). Accounting for any PICU technology (mechanical ventilation, non-invasive ventilation, vasoactive infusion, renal replacement therapy, or ECMO), 337,893 (54.2%) patients received intensive care therapies during the hospital stay that is generally only provided in the PICU. This proportion is increasing over time (Supplemental Digital Content 2). Trends in PICU resource use are shown in Supplemental Digital Content 2.

Systems-Level Data

The total number of PICU encounters increased in each of the three two-year epochs examined during the study period, from 199,088 in 2014-2015, to 204,836 in 2016-2017, and 219,587 in 2018-2019. During the study period, the pediatric population of the United States remained stable or decreased (12). Over the six year period, there were 141.4 PHIS PICU encounters per year per 100,000 children. The overall percentage of encounters involving the PICU was 13.8%. This increased over time across the three epochs from 13.3% to 14.3% ($p<0.001$), as did the percentage of total hospital days spent in the PICU ($p<0.001$). PICU beds comprise approximately 15% of reported beds in PHIS hospitals, but accounted for 30.6% of hospital occupancy from institutions that reported occupancy.

Total costs for all PICU admissions increased significantly over each of the three epochs, although the geometric mean PICU cost per patient encounter was not significantly different ($22,847 [GSD: 3.4] in 2014-2015, $22,503 [GSD: 3.5] in 2016-2017, and $22,043 [GSD: 3.5] in 2018-2019). PICU costs accounted for 41.7% of total hospitalization costs per patient admitted to the PICU. Over half (51%) of the PICU costs were primarily "other" costs (e.g., room charges, nursing) compared to clinical (16%), imaging (5%), laboratory (11%), and pharmacy (6%) costs. Physician professional fees are not accounted for in these costs. This pattern was consistent across the epochs. For patients admitted to the PICU, 66.9% of total hospitalization costs were accrued during the time the patient spent in the PICU. Change in PICU utilization as a proportion of all hospitalizations over time are shown in Table 4.

Across participating hospitals, a median of 30.1% [IQR: 24.3%-34.4%] of all hospital days were accounted for by children who spent time in the PICU during that admission, ranging from 15.1% to 63.5% (Figure 1). Variation in interventions are shown in Figure 2. Institutions with a PICU fellowship program (35/43; 81.4% hospitals) accounted for 88.5% of PICU admissions, and 90.2% of PICU bed days. Hospitals with a PICU fellowship cared for patients that had a higher resource use intensity score (H-RISK: 6.9 vs. 5.4, $p<.001$).

Discussion:

In this retrospective cross-sectional study of a large administrative data set of large United States children's hospitals, we identified 623,511 encounters receiving PICU care in United States children's hospitals over a six-year period. This represented 13.8% of total pediatric hospital encounters during that period. PICU admissions, both in raw number and as a proportion of pediatric hospitalizations, increased over time. Wide variation was seen in the

proportion of days spent in the PICU compared to total hospital days across the PHIS-participating institutions. This variation may be due to differing institutional policies governing provision of therapies in the PICU compared to the general ward or regional availability of services, specifically including non-invasive positive pressure ventilation, pediatric rehabilitation, or home nursing.

Given that the intensity of resource use for patients admitted to the PICU increased over time, as noted by the H-RISK score, and the increase in PICU-specific technologies the increase in PICU exposure may be attributable to a higher acuity of patients requiring care. However, this increased illness severity did not consistently manifest as additional procedures. For example, central venous catheters and vasoactive infusions decreased across all epochs of study period. Although a larger number of patients received non-invasive ventilation over time, this did not result in a concomitant decrease in invasive ventilation, which is consistent with previously published data in children with bronchiolitis (13). Additionally, with the increase in total number of PICU beds nationally, it is unclear whether the increase in total PICU admissions over the study period represents expanded use of new capacity or additional capacity needs that are not being met even with the increase in overall number of PICU beds. Although we were unable to assess capacity in this study, we do know that PICU bed numbers have increased 16% from 2008-2018, primarily at large children's hospitals, such as those participating in PHIS. (Cushing).

Previous work has provided data regarding the number of children receiving pediatric critical care services in specific populations in the US, or in other countries. For example, a population-based study of all pediatric hospitalizations in Australia identified that 1.5% of admissions involved PICU care (14). A birth cohort from Olmsted County, Minnesota (USA)

identified that 6.1% of children received care in the PICU over a four year period, usually in the first year of life (15). Our study identified a rate of 141.35 admissions per year per 100,000 pediatric population. This is likely an underestimate since PHIS hospitals do not account for all pediatric admissions in the United States but likely account for the vast majority of PICU beds in the United States (3). However, this rate is similar to contemporary population data seen in Ireland and the United Kingdom (16).

The case-complexity and resource intensity for PICU admissions has increased over time, however the relative cost of care per patient has remained static. This finding may be related to increased options for non-invasive monitoring and intervention as well as increased attention to quality measures like central line-associated bloodstream infections. The lack of change in cost per PICU patient may additionally reflect efficiency in the health care system to contain costs, perhaps via increased outpatient capacity and complexity, the use of step-down or transitional units, or increased efficiency with existing resources. The wide variation among participating hospitals, however, presents a meaningful opportunity for improvement by reducing variability. The PICU cost of care in this study is heavily influenced by the staffed room cost itself, which underscores the need for clear and consistent criteria for both PICU admission as well as PICU transfer/discharge. Thus, there is also an economic motivation to ensure that PICU beds are only used when medically indicated. Our findings of decreased procedural exposures and increased non-invasive mechanical ventilation are similar to recent studies of pediatric critical care resource use in the United States (17).

Previous work has shown increased risk for critical illness in children exposed to poverty and social deprivation both in the United States and internationally (18, 19). Our data, using the Child Opportunity Index to indicate socioeconomic and sociodemographic needs, parallel this

finding, with children in the High and Very High quintiles underrepresented among critically ill children and those from Low and Very Low quintiles overrepresented. Children from communities with high need disproportionately require PICU services. These data can inform future capacity planning needs and may justify the need for better regionalization of critical care resources for children. Local institutions may need to consider their community sociodemographic and socioeconomic referral base when planning for capacity of critical care beds and hospital staffing models, and researchers should continue to examine this area.

These findings are subject to limitations. First, PHIS is an administrative data set of primarily standalone children's hospitals. Although a subset of all the PICUs in the United States, the PHIS participating hospitals likely represent a large proportion of all PICU beds in the United States (3). Children cared for at children's hospitals are likely more complex than those cared for at general hospitals (20). This is particularly likely to be true for subspecialty services, such as cardiac or other types of surgical interventions. Therefore, these data may not be generalizable to the provision of critical care in other settings. Second, this study defined PICU admission based on a patient being admitted to a specific physical location, not necessarily the provision of critical care services. It is notable, however, that 54.2% of patients in this study received care that is generally only provided in the PICU which suggests that PICU care was initiated for a specific clinical need that is not generally provided on a general hospital ward. Finally, it is possible that the six year study period is not long enough to see consistent changes in the studied clinical practices. Although the 2-year epochs are arbitrarily divided, the trends over time are clear and consistent. Despite these limitations, these data provide a valuable insight into the evolution of the pediatric critical care population over time in a cohort of large independent children's hospitals.

Conclusions:

The proportional use of PICU beds is increasing over time. Case-based resource use and complexity of pediatric patients are also increasing. Despite the higher use of PICU resources, the costs of PICU care per patient have remained static. Children from communities with highest socioeconomic and sociodemographic needs disproportionately require PICU services. These data may help to inform current PICU resource allocation and future PICU capacity planning.

References:

1. Randolph AG, Gonzales CA, Cortellini L, Yeh TS. Growth of pediatric intensive care units in the United States from 1995 to 2001. *J Pediatr*. 2004;144(6):792-798. doi:10.1016/j.jpeds.2004.03.019

2. Odetola FO, Clark SJ, Freed GL, Bratton SL, Davis MM. A national survey of pediatric critical care resources in the United States. *Pediatrics*. 2005;115(4):e382-e386. doi:10.1542/peds.2004-1920

3. Horak RV, Griffin JF, Brown AM, et al. Growth and Changing Characteristics of Pediatric Intensive Care 2001-2016. *Crit Care Med*. 2019;47(8):1135-1142. doi:10.1097/CCM.0000000000003863

4. Horak RV, Alexander PM, Amirnovin R, et al. Pediatric Cardiac Intensive Care Distribution, Service Delivery, and Staffing in the United States in 2018. *Pediatr Crit Care Med*. 2020;21(9):797-803. doi:10.1097/PCC.0000000000002413

5. LaRovere KL, Murphy SA, Horak R, et al. Pediatric Neurocritical Care: Evolution of a New Clinical Service in PICUs Across the United States. *Pediatr Crit Care Med*. 2018;19(11):1039-1045. doi:10.1097/PCC.0000000000001708

6. American Hospital Association. "Fast Facts on U.S. Hospitals, 2021." Published January 14, 2021. Accessed August 20, 2021. <https://www.aha.org/system/files/media/file/2021/01/Fast-Facts-2021-table-FY19-data-14jan21.pdf>

7. Frankel LR, Hsu BS, Yeh TS, et al. Criteria for Critical Care Infants and Children: PICU Admission, Discharge, and Triage Practice Statement and Levels of Care Guidance. *Pediatr Crit Care Med*. 2019;20(9):847-887. doi:10.1097/PCC.0000000000001963

8. Macy ML, Hall M, Shah SS, et al. Differences in designations of observation care in US freestanding children's hospitals: are they virtual or real?. *J Hosp Med*. 2012;7(4):287-293. doi:10.1002/jhm.949

9. Noelke C, McArdle N, Baek M, et al. Child Opportunity Index 2.0 Technical Documentation. Accessed August 13, 2021. <http://new.diversitydatakids.org/sites/default/files/202001/ddk_coi2.0_technical_documentation_20200115_1.pdf>

10. Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project. "Clinical Classifications Software Refined (CCSR)." Accessed August 13, 2021. <https://www.hcup-us.ahrq.gov/toolssoftware/ccsr/ccs_refined.jsp>

11. Richardson T, Rodean J, Harris M, Berry J, Gay JC, Hall M. Development of Hospitalization Resource Intensity Scores for Kids (H-RISK) and Comparison across Pediatric Populations. *J Hosp Med*. 2018;13(9):602-608. doi:10.12788/jhm.2948

12. United States Census Bureau. "Child Population: Number of Children (in Millions) Ages 0-17 in the United States by Age, 1950-2020 and Projected 2021-2050." Accessed November 11, 2021. <https://www.childstats.gov/americaschildren/tables/pop1.asp>

13. Shanahan KH, Monuteaux MC, Nagler J, Bachur RG. Noninvasive Ventilation and Outcomes in Bronchiolitis. *Crit Care Med*. 2021;49(12):e1234-e1240. doi:10.1097/CCM.0000000000005210

14. Ibiebele I, Algert CS, Bowen JR, Roberts CL. Pediatric admissions that include intensive care: a population-based study. *BMC Health Serv Res*. 2018;18(1):264. Published 2018 Apr 10. doi:10.1186/s12913-018-3041-x

15. Crow SS, Undavalli C, Warner DO, et al. Epidemiology of Pediatric Critical Illness in a

Population-Based Birth Cohort in Olmsted County, MN. *Pediatr Crit Care Med*. 2017;18(3):e137-e145. doi:10.1097/PCC.0000000000001084
16. Healthcare Quality Improvement Partnership PICANet. "Paediatric Intensive Care Audit Network: Annual Report 2020." Published February 2021. Accessed November 11, 2021. <https://www.picanet.org.uk/wp-content/uploads/sites/25/2021/02/PICANet2020_AnnualReportSummary_v1.0.pdf>
17. Ross PA, Engorn BM, Newth CJL, Gordon C, Soto-Campos G, Bhalla AK. Declining Procedures in Pediatric Critical Care Medicine Using a National Database. *Crit Care Explor*. 2021;3(3):e0359. Published 2021 Mar 5. doi:10.1097/CCE.0000000000000359
18. Andrist E, Riley CL, Brokamp C, Taylor S, Beck AF. Neighborhood Poverty and Pediatric Intensive Care Use. *Pediatrics*. 2019;144(6):e20190748. doi:10.1542/peds.2019-0748
19. Parslow RC, Tasker RC, Draper ES, et al. Epidemiology of critically ill children in England and Wales: incidence, mortality, deprivation and ethnicity. *Arch Dis Child*. 2009;94(3):210-215. doi:10.1136/adc.2007.134403
20. Simon TD, Berry J, Feudtner C, et al. Children with complex chronic conditions in inpatient hospital settings in the United States. *Pediatrics*. 2010;126(4):647-655. doi:10.1542/peds.2009-3266

Figure Legends:

Figure 1: Hospital-level variation in the percentage of days spent in the PICU. Values ranged from 15.1% to 63.5% across the participating sites. Median (indicated by vertical line) was 30.1%. Hospitals are listed by PICU admission volume.

Figure 2: Hospital-level variation in the percentage of PICU encounters receiving (A) mechanical ventilation; (B) non-invasive positive pressure ventilation; (C) vasoactive infusions; and (D) central venous catheters. The vertical lines indicate median proportion of PICU encounters receiving each therapy. Hospitals are listed by PICU admission volume and are in the same order for each panel.

Figure 1

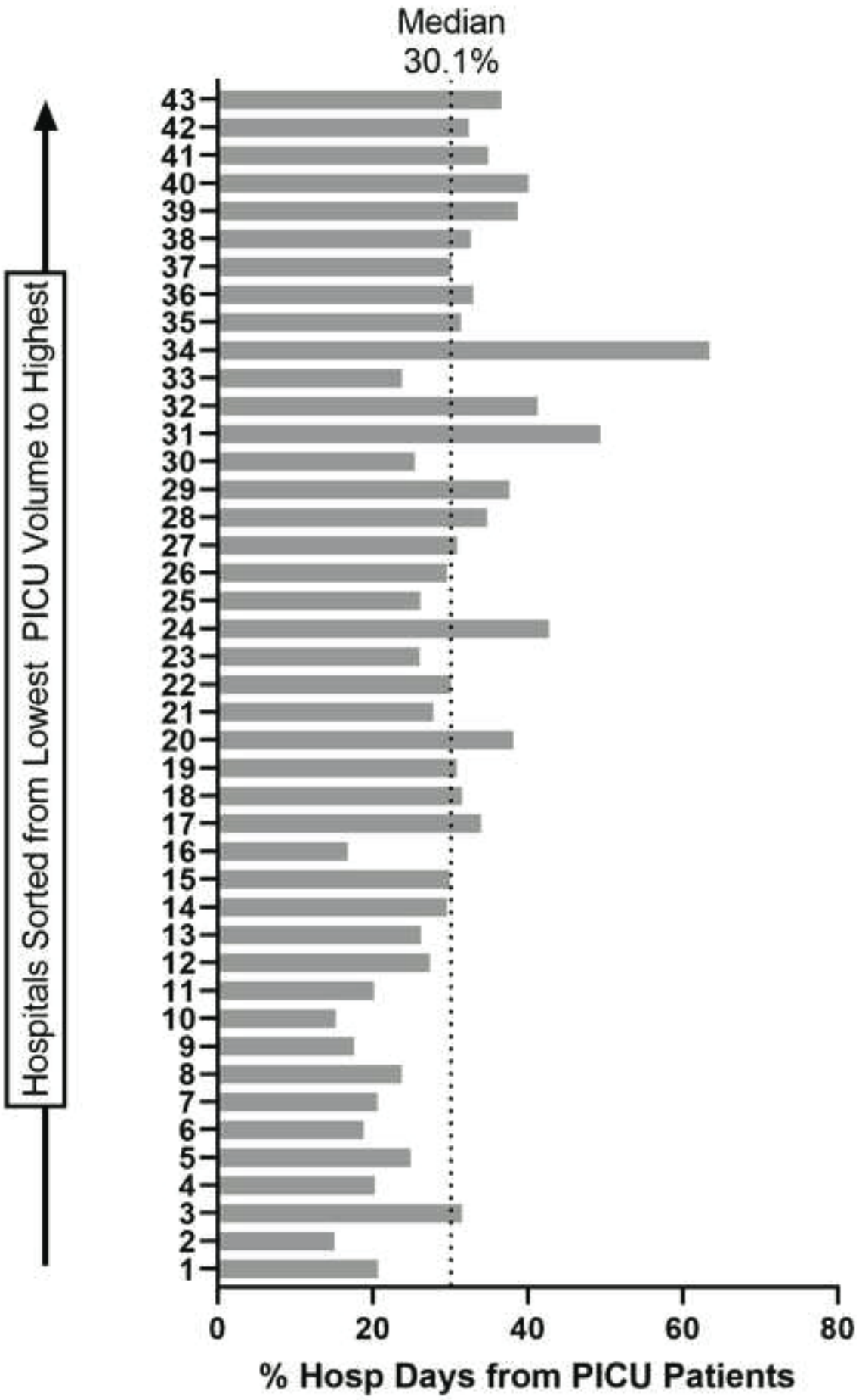

Figure 2

Click here to access/download;Figure;Figure 2.tif

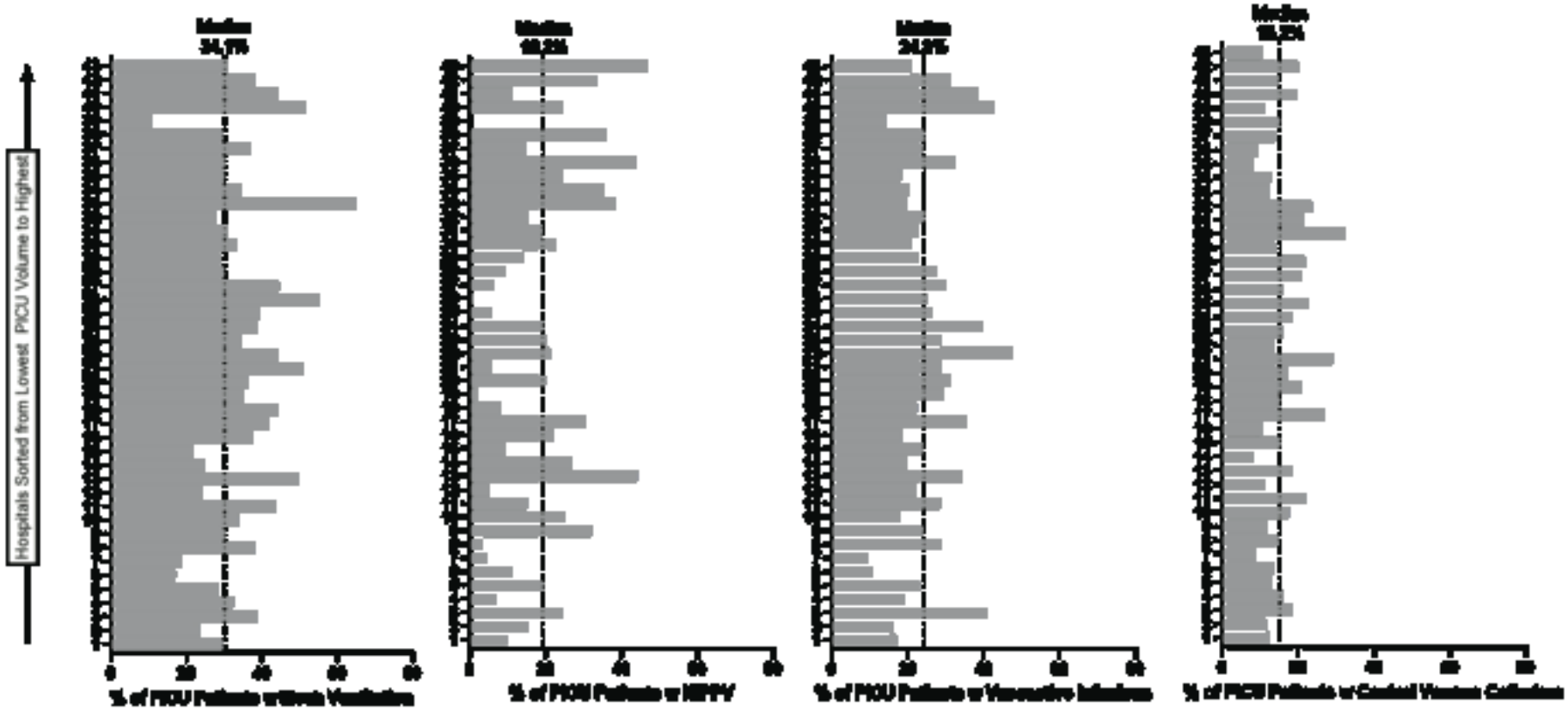

Table 1

Table 1. Demographic and clinical characteristics of included PICU encounters over time. Data separated by two year epochs are available in Supplemental Digital Content 1. Values are n (%) unless otherwise specified.

Characteristic	**Overall (n=623,511)**
Age, years	
<1	169297 (27.2)
1-4	163840 (26.3)
5-9	93310 (15)
10-15	119747 (19.2)
16-21	67730 (10.9)
22-35	8184 (1.3)
36-64	1403 (0.2)
Female	279056 (44.8)
Payor	
Government	350785 (56.3)
Private	240421 (38.6)
Other	32305 (5.2)
Hospital Census Region	
Midwest	165835 (26.6)
Northeast	94232 (15.1)
South	214995 (34.5)
West	148449 (23.8)
Number of Complex Chronic Conditions	
0	202341 (32.5)
1	191078 (30.6)
2	178766 (28.7)
≥3	51326 (8.2)
Child Opportunity Index	
Very Low	143326 (23)
Low	127141 (20.4)
Moderate	124518 (20)
High	113193 (18.2)
Very High	115333 (18.5)
PICU Mortality	14767 (2.4)

PICU = pediatric intensive care unit

Table 2

Table 2. Most common principle diagnosis categories as assessed by the Clinical Classification Software (10) across time for PICU encounters. Italicized cells represent overlap in most common diagnoses between PICU encounters and non-PICU encounters during that epoch.

Rank	**2014-2015 (n=199,088)**	**2016-2017 (n=204,836)**	**2018-2019 (n=219,587)**
1	Cardiac and circulatory congenital anomalies (N=24,021, 12.1%)	Cardiac and circulatory congenital anomalies (N=22,762, 11.1%)	Respiratory failure; insufficiency; arrest (N=31,456, 14.3%)
2	Respiratory failure; insufficiency; arrest (N=13,280, 6.7%)	Respiratory failure; insufficiency; arrest (N=20,912, 10.2%)	Cardiac and circulatory congenital anomalies (N=22,786, 10.4%)
3	*Asthma (N=10,228, 5.1%)*	*Acute bronchiolitis (N=11,088, 5.4%)*	*Acute bronchiolitis (N=12,670, 5.8%)*
4	*Acute bronchiolitis (N=9109, 4.6%)*	*Epilepsy; convulsions (N=8293, 4%)*	Septicemia (N=10,333, 4.7%)
5	*Epilepsy; convulsions (N=8057, 4%)*	Septicemia (N=7765, 3.8%)	*Epilepsy; convulsions (N=8542, 3.9%)*
6	*Other congenital anomalies (N=7514, 3.8%)*	*Asthma (N=7494, 3.7%)*	*Asthma (N=7637, 3.5%)*
7	*Pneumonia (N=7263, 3.6%)*	*Other congenital anomalies (N=7177, 3.5%)*	Diabetes mellitus with complications (N=7286, 3.3%)
8	Complication of device; implant or graft (N=6844, 3.4%)	*Pneumonia (N=7048, 3.4%)*	*Other congenital anomalies (N=7134, 3.2%)*
9	Diabetes mellitus with complications (N=6237, 3.1%)	Diabetes mellitus with complications (N=6725, 3.3%)	*Pneumonia (N=6496, 3%)*
10	Septicemia (except in labor) (N=6105, 3.1%)	Complication of device; implant or graft (N=5314, 2.6%)	Complication of device; implant or graft (N=5589, 2.5%)

Table 3

Table 3. PICU resource utilization during the study period. Data separated by two year epochs are available in Supplemental Digital Content 2. Values are n (%) unless otherwise specified.

Resource	Overall (n=623,511)
PICU Length of Stay, days (geometric mean, SD)	2.7 (2.8)
Mechanical ventilation	221099 (35.5)
Non-invasive ventilation	129312 (20.7)
ECMO	8130 (1.3)
Arterial lines	23855 (3.8)
Central venous catheters	100296 (16.1)
Peripherally inserted central catheters	61809 (9.9)
Vasoactive infusions	161674 (25.9)
Renal replacement therapy	11371 (1.8)
Combined PICU intervention[1]	337893 (54.2)
Any 365 day readmission following hospital discharge	248534 (39.9)
PICU 365 day readmission following hospital discharge	142185 (22.8)

[1]Mechanical ventilation, non-invasive positive pressure ventilation, ECMO, renal replacement therapy, vasoactive infusions

PICU = pediatric intensive care unit; ECMO = extracorporeal membrane oxygenation

Table 4. Change in PICU utilization as a proportion of all hospitalizations and hospital days over time. Monetary values have been adjusted to 2019 United States dollars. All comparisons across epochs were significant ($p<0.001$).

Utilization	**Overall**	**2014-2015**	**2016-2017**	**2018-2019**
Hospitalizations				
Total	4,525,527	1,492,633	1,499,663	1,533,231
PICU	623,511	199,088	204,836	219,587
% PICU	13.8%	13.3%	13.7%	14.3%
Hospital Days				
Total	23,806,454	7,566,575	7,933,285	8,306,594
PICU	7,273,750	2,227,594	2,397,209	2,648,947
% PICU	30.6%	29.4%	30.2%	31.9%
Costs (in billions of United States dollars)				
Total	111.9	33.0	37.1	41.9
PICU	46.6	13.4	15.4	17.8
% PICU	41.7%	40.7%	41.4%	42.6%

PICU = pediatric intensive care unit