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Multi-institutional profile of adults admitted to pediatric intensive care units

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Abstract

Importance—Growing numbers of persons with childhood-onset chronic illnesses are surviving to adulthood. Many use pediatric hospitals for their inpatient needs. To our knowledge, the prevalence and characteristics of adult pediatric intensive care unit patients have not been reported.

Objectives—To estimate the proportion of adults admitted to pediatric intensive care units (PICUs), characterize them, and compare them with older adolescents.

Design—One-year cross-sectional analysis.

Setting—Pediatric intensive care units in the United States that participated in the Virtual Pediatric Intensive Care Unit Systems.

Participants—Pediatric intensive care unit patients 15 years or older admitted in 2008.

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Main Outcome Measures—We compared adults with adolescents across clinical characteristics and outcomes. Mixed-effects logistic regression was used to estimate the independent association of age with PICU mortality.

Results—Seventy PICUs had 67 629 admissions; 1954 admissions (2.7%) were patients 19 years or older; and 9105 admissions (13.5%) were patients aged 15 to 18 years. The proportion of adults (_19 years) varied considerably by PICU (range, 0%–9.2%). As age increased, the proportion of patients who had a complex chronic condition and planned or perioperative admissions increased; the proportion of trauma-related admissions decreased. Patients aged 21 to 29 years had a 2 times (95% CI, 1.3–3.2; *P*=.004) greater odds of PICU mortality compared with adolescent patients, after adjusting for Paediatric Index of Mortality score, sex, trauma, and having a complex chronic condition. Being 30 years or older was associated with a 3.5 (95% CI, 1.3–9.7; *P*=.01) greater odds of mortality.

Conclusions and Relevance—In this multi-institutional study, adults constituted a small but high risk proportion of patients in some PICUs, suggesting that these PICUs should have plans and protocols specifically focused on this group.

Keywords

Intensive Care Units; Pediatric; Adult; Adolescent; Chronic Disease

Introduction

Growing numbers of persons with childhood-onset chronic illnesses are surviving to adulthood. Pediatric and adult medicine stakeholders have highlighted the importance of transitioning young adults with special health care needs from child- to adult-oriented health care.[1234] Transitioning care may occur at different ages, depending on many factors, including access to appropriate adult care and patient preference. Although a focus on outpatient care is essential for successful transition,[45] the transition of inpatient care is also necessary. However, some patients with childhood-onset chronic illnesses, such as congenital heart disease, cystic fibrosis, and sickle cell disease, continue to receive inpatient care from pediatrics hospitals well into adulthood.[67891011]

While adults presenting to pediatric emergency departments or admitted to pediatric hospitals have been described[612], to our knowledge, the extent to which and under what circumstances adults are admitted to pediatric intensive care units (PICUs) has not been addressed. Neither has there been a description of their clinical characteristics or outcomes. This information will improve our understanding of how this population impacts PICU case mix, outcome performance measures, and organizational needs and help clinicians to better tailor strategies for transitioning patients to adult services. To characterize adults admitted to US PICUs and compare them with adolescents, we conducted a retrospective multi-institutional cohort study of PICU patients 15 years and older.

Methods

Data Source

We performed an analysis of all patients 15 years and older who were admitted in 2008 to 70 US PICUs that participated in the Virtual Pediatric Intensive Care Unit Systems (VPS). The VPS is a collaboration between the Children's Hospital Association, National Outcomes Center of the Children's Hospital and Health System in Wisconsin, and Children's Hospital Los Angeles. The VPS database contains encounter-level information on all admissions entered by trained clinicians at the participating sites. Sites submit data for their medical/

surgical PICUs and pediatric cardiac intensive care units (ICUs); data are not collected from neonatal ICUs, intermediate or specialized noncritical care units, or general wards. Annual certification of data definitions, routine interrater reliability testing, and automated and manual data cleaning queries are used to ensure data quality. All institutions are required to submit several demographic and clinical data elements. Some sites voluntarily submitted additional characteristics. These included race (46 sites), secondary diagnoses (68 sites), primary reason for admission (49 sites), trauma (55 sites), airway/ventilatory procedures (32 sites), and functionality scores (21 sites). Data for mandatory characteristics were submitted for every admission by each site. Similarly, when a site elected to report a nonmandatory characteristic, data were submitted for every admission.

On approval of our research proposal, data were provided by VPS. No endorsement or editorial restriction of the interpretation of these data or opinions of the authors have been implied or stated. We received an exemption from the University of California, San Francisco Committee on Human Research for this study.

Patient Characterization

Patients were stratified into 4 age categories: 15 to 18, 19 to 20, 21 to 29, and 30 years or older. These age categories were chosen because we considered 15 to 18 years the upper end of childhood. Nineteen to 20 years can be considered a transition period, while 21- to 29-year-old patients are adults sometimes still cared for by pediatric providers. We considered 30 years or older beyond young adulthood and the age range for the pediatric health care system. We presented the aggregate number and proportion of PICU patients and admissions, as well as the median proportions with interquartile ranges (IQRs) among the VPS sites.

We collected patient characteristics of each PICU admission. When information was available for only a subgroup of the admissions and sites, we noted this in the text or Tables. Demographic characteristics included age, sex, and race. Clinical characteristics included type of admission (unplanned, perioperative, or trauma), reason for admission by primary organ system affected, patient origin and disposition, whether admission was to a PICU with more than 1000 annual admissions, whether positive pressure ventilation was used, severity of illness, and presence of any complex chronic condition. Positive pressure ventilation was defined as conventional mechanical ventilation, high-frequency ventilation, and bi-level or continuous positive airway pressure via tracheal, mask, or nasal interface. Severity of illness was assessed using a predicted probability of mortality estimated with the Paediatric Index of Mortality 2.[13] Complex chronic conditions were defined according to the Feudtner et al definition[14] but were identified among VPS diagnoses using a list of VPS codes we developed and detailed elsewhere.[15] Using data from PICUs that provided secondary diagnoses, we identified specific high-morbidity childhood-onset chronic conditions that are no longer lethal in childhood but require continuing management in adulthood. Using data from PICUs that provided procedural information, we also identified procedures and operations classified by organ system.

We also assessed outcomes of care: functional status, length of stay, and mortality. Functional outcomes were assessed with preadmission and discharge Pediatric Overall and Cerebral Performance Categories (POPC and PCPC)[16] from those units that reported this information. The POPC and PCPC scores range from 1 (normal function) to 6 (brain death). Scores of 2, 3, and 4 indicate mild, moderate, and severe disability, respectively. A score of 5 indicates coma or vegetative state. Length of stay was measured in days from time of PICU admission to PICU discharge. Finally, we assessed PICU mortality.

Statistical Analyses

We calculated proportions and 95% confidence intervals or medians and IQR for demographic and clinical characteristics, stratified by age categories. Similarly, we calculated proportions and 95% confidence intervals for specific chronic and acute conditions or categories, as well as for procedures and operations classified by organ system. Bivariate statistics were calculated using Pearson chi^2 test or Kruskal-Wallis rank test when appropriate.

We estimated the association between age and PICU mortality by calculating a prevalence risk ratio and the risk difference for PICU mortality of patients 19 years or older compared with those aged 15 to 18 years. To estimate the adjusted association, we then fitted a mixed-effects logistic regression model, using the adolescent and adult cohort from units that supplied secondary diagnoses and trauma data. Random effects were at the hospital level. Our primary predictors were the age categories, and we adjusted for sex, trauma, severity of illness (Paediatric Index of Mortality 2) score, and presence of any complex chronic condition. Model diagnostics were performed to ensure accuracy and goodness of fit. Statistical significance was determined using a *P* value of <.05 and by constructing 95% confidence intervals. Stata version 12 (StataCorp) was used for statistical analyses.

Results

Site and Patient Characteristics

In 2008, 70 VPS PICUs were located in 32 states; these PICUs represented approximately 30% of the Children's Hospital Association-designated children's hospitals in the United States.[17] Fifteen PICUs (21%) had fewer than 10 beds, 30 (43%) had 11 to 20 beds, and 25 (35%) had 21 or more beds. Twenty-eight PICUs (40%) had more than 1000 annual admissions. Twenty-nine PICUs (41%) were situated in freestanding children's hospitals; 58 (83%) were level I units.[18] Fifty-three PICUs (76%) were affiliated with a pediatric residency program and 28 (40%), with a critical care fellowship.

These PICUs had 50 786 patients with 67 629 admissions in 2008. Of these, 1954 admissions (2.7%) were patients 19 years or older; 9105 admissions (13.5%) were patients aged 15 to 18 years. Further breakdown of number of admissions by age group is shown in Table 1. The oldest patient was 56 years of age. The proportion of adults admitted to each PICU varied widely; the median proportion of admissions for patients 19 years or older was 1.8% (IQR, 0.5%–3.2%; range, 0%–9.2%); aged 19 to 20 years, 1% (IQR, 0.4%–2.1%); and 21 years or older, 0.6% (IQR, 0%xy11%).

Additional patient characteristics by age category are presented in Table 1. Admission characteristics and PICU outcomes are presented in Table 2. As the age category of admissions increased, there were higher proportions of patients who were white, had a complex chronic condition, and had planned or perioperative admissions. Also, as age category increased, there were lower proportions of patients who were admitted for trauma-related reasons.

Conditions and Procedures

The proportions of specific chronic and acute conditions among our study admissions are presented in Table 3 and Table 4, respectively. Several chronic conditions were more common among adults than adolescent PICU patients, including congenital cardiac abnormalities (13.5% vs 4.8%; $P < .001$), generalized developmental delay (10.4% vs 4.7%; $P < .001$), and epilepsy (12.9% vs 7.4%; $P < .001$). Acute lung injury and respiratory distress syndrome were more common in adults (18.1%) compared with adolescents (11.4%; $P <$.

001). The proportions of admissions for patients who underwent procedures and operations by age category are presented in Table 5.

Outcomes

The POPC and PCPC scores were available from 21 units for 3542 admissions (32%) and are presented in Table 1. In general, adults had worse preadmission functionality, as evidenced by higher median overall scores (moderate disability vs no disability in adolescents) or wider distributions of POPC and PCPC scores. On discharge, the median POPC score of adolescents was worse (mild disability) than preadmission POPC score (no disability). The preadmission and discharge POPC scores did not change for adults.

The PICU mortality for the entire cohort was 2.7%; mortality increased significantly with age categories ($P < .001$). Adults 19 years or older had a 126% higher incidence of PICU mortality than adolescent patients did (risk ratio, 2.3; 95% CI, 1.8–2.9; risk difference, 2.8%; 95% CI, 1.8%–3.9%). To address the impact of trauma and having a complex chronic condition on mortality, we used a subgroup of 8828 admissions (81%) from 63 units (overall mortality, 2.6%) that supplied secondary diagnoses and trauma data to fit a regression model of PICU mortality. After adjusting for these variables plus Paediatric Index of Mortality 2 score and sex, patients aged 21 to 29 years had a 2.02 times (95% CI, 1.26–3.24; $P = .004$) greater odds of PICU mortality compared with adolescents. Being 30 years or older was associated with a 3.55 (95% CI, 1.30–9.73; $P = .01$) greater adjusted odds of PICU mortality. Age 19 to 20 years was not statistically associated with PICU mortality (adjusted odds ratio, 1.34; $P = .21$) compared with age 15 to 18 years. Finally, as age category increased, the median length of stay also increased significantly ($P < .001$). The median length of stay for adults (1.9 days) was half a day longer than for adolescents (1.4 days).

Comment

To our knowledge, this is the first multi-institutional study to characterize adults admitted to PICUs. Commonly, adult patients are excluded from studies that describe pediatric inpatient populations and from most pediatric inpatient databases. We found that approximately 2% of PICU patients and 3% of admissions from this cohort were adults 19 years or older. There was wide variation in the proportion of adult patients across PICUs, from zero to 9%. Adults were generally admitted to PICUs with higher patient volume in greater proportions. Adult PICU patients had greater severity of illness and preadmission disability, longer lengths of stay, and higher mortality compared with younger patients. We also observed that the majority of adult admissions were planned and perioperative, and the proportion appeared to be higher with older corresponding age.

The proportion of adult patients in our PICU cohort is similar to the general hospital population presented by Goodman et al.[10] They showed that 1.8% of discharges from the inpatient services of 41 tertiary children's hospitals were patients older than 18 years and 0.8% of patients and 1% of discharges were older than 21 years. These adults also had higher rates of chronic conditions compared with younger patients. Our study adds to the current literature by focusing on PICU patients, characterizing their type of and reasons for PICU admissions, and describing adult patients' chronic conditions in greater detail.

After age 18 years, close to 80% of PICU patients had a complex chronic condition, compared with 53% of adolescents. These chronic conditions increase a person's risk for critical illness and need for critical care.[15] Notably, many (20%) adult PICU patients 21 years or older had congenital cardiac abnormalities and/or had cardiac procedures or operations. Goodman et al[10] reported an even larger proportion of adult inpatients with congenital heart disease (29%). Cerebral palsy, generalized developmental delay, and

epilepsy were other relatively common chronic conditions in our adult cohort. The higher proportion of adults with certain childhood-onset chronic conditions may reflect the inability or unwillingness to transition to adult care or greater need for critical care services as certain conditions progress. Lower proportions may indicate more successful transitioning of certain populations or higher mortality at older ages in others (eg, muscular dystrophy).

Although this study cannot determine the reasons for persistent care of adults in PICUs, the disproportionate number with chronic conditions suggests some adults with such conditions may preferentially go to PICUs. The reasons are likely multifactorial and similar to the reasons adults use pediatric services in general. Young adults with chronic conditions and their families often have preexisting relationships with pediatric providers and facilities that have expertise and specialized care unique to those conditions.[1920] They may then be more likely to be admitted for their perioperative and critical care needs to PICUs with which those providers are affiliated. The number of adults in the PICUs may be a proxy for a lack of disease-specific resources and expertise in adult ICUs (eg, perioperative care in congenital heart disease). Other reasons for persistent care of adults in PICUs likely include a lack of planning on the part of pediatric providers,[921] a lack of adult-oriented providers with adequate training and experience caring for childhood-onset chronic conditions,[19202223] a lack of collaboration between pediatric and adult providers, and other factors.[2425]

The higher mortality of adult PICU patients may be due to progression of certain life-limiting childhood-onset conditions to a terminal stage or, for a smaller segment, adult-onset conditions that impact mortality. These patients may remain under the care of pediatricians for purposes of end-of-life care and despite advanced age. The higher risk-adjusted PICU mortality of adults compared with adolescents and the considerable institutional variability in the proportion of adults have important implications for PICU case mix and benchmarking. Case-mix imbalances between institutions with high or low proportions of adults may unduly impact individual PICUs' predicted mortality and lead to incorrect conclusions regarding outcome performance. A potential solution to case-mix imbalances includes calculating PICU performance for just children. It is unclear if pediatric risk-adjustment systems are valid for adults in PICUs, and adult systems[262728] may not be valid for adults with childhood-onset chronic conditions.

Our study does not answer the questions of if and when all adults should be transitioned or if the quality of care is better in pediatric or adult ICUs. Assuming the survival of persons with childhood-onset chronic conditions will continue to increase, it does suggest that high-risk adults will continue to be a clinically important patient population, especially for larger PICUs. Pediatric intensive care units, particularly those associated with congenital cardiac programs, should anticipate providing more critical and perioperative care to these patients. At the same time, as efforts to transition these patients to adult care become more widespread and effective, some of these patients may move from PICUs to adult ICUs. Thus, our study also illustrates the type of patients that adult ICUs will need to prepare for as transition efforts become more successful.

Our study has a number of limitations. First, it is a 1-year cross-sectional study. Therefore, we are unable to comment on trends in the proportion of adult PICU patients. The proportion of adults in our sample may have decreased with advancing age for various unstudied reasons—transition to adult care, death, and relocation, for example. Second, the PICUs included in our database may not be representative of all PICUs in the United States. Because institutional data were only provided in the aggregate, we could not stratify by types of PICUs. Also, a limited number of data variables were not submitted by every PICU, although the vast majority of information was captured completely. Third, any postulations on the relative appropriateness of admitting adults to PICUs based on these findings should

be made in light of the fact that we do not know what adult critical care options, if any, these patients may have had. Similarly, we do not have data on adults with childhood-onset chronic conditions who use adult ICUs. Therefore, we do not know how the characteristics of our adult PICU patients compare with those of the overall population of adults with childhood-onset conditions needing ICU care. Lastly, our estimate of the increased risk of PICU mortality associated with age 21 years or older was adjusted using a pediatric severity-of-illness scoring system. Neither Paediatric Index of Mortality 2 score nor Pediatric Risk of Mortality score[29]—the 2 most widely used pediatric severity-of-illness systems—have been validated for adults. Nevertheless, PICUs are using these systems to risk adjust outcomes for their adult patients.

Conclusions

The combination of increasing survival of young adults with chronic conditions and possibly underdeveloped transitioning efforts has resulted in a small, but clinically important, cohort of adults with critical illness who receive care in PICUs. Characterizing the extent and patterns of pediatric critical care use by adults is helpful for planning both the provision of future clinical services and further research to evaluate the success of transition efforts. Additional research is needed to examine the trends of adult PICU admissions, the reasons for institutional variation, how to effectively transition suitable adult populations from pediatric to adult critical care services, their costs of care, and if the quality of care is different for these adults when cared for in adult ICUs.

It is unclear if PICUs or adult ICUs are the best place to meet the critical care needs of adults with childhood-onset chronic conditions, and certain conditions may be better cared for in particular units. Pediatric facilities, including PICUs, often do not have the specific resources and expertise needed to optimize the care of adult-acquired conditions. On the other hand, PICUs may be more capable than adult ICUs of providing the specialized care needed to address their underlying childhood-onset chronic conditions. Regardless, as the number of adults with childhood-onset chronic conditions grows, PICUs will need to prepare for increasingly older patients and adult ICUs will increasingly need to care for these adults. Both types of units will need to make greater efforts to collaborate on research and training of providers to meet their unique care needs and on guidelines that help direct specific types of adult patients to the unit type where those needs can best be met.

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Abbreviations

CI	confidence interval
IQR	interquartile range
LOS	length of stay

PCPC	Pediatric Cerebral Performance Category
PIM	Paediatric Index of Mortality
PICU	pediatric intensive care unit
POPC	Pediatric Overall Performance Category
PPV	positive pressure ventilation
VPS	Virtual Pediatric Intensive Care Unit Systems

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Table 1

Patient characteristics and functional status by age groups

Characteristic, % admissions (95% CI)	15–18 years n=9, 105	19–20 years n=1, 102	21–29 years n=652	≥30 years n=100
Admissions	83.1 (82.4–83.8)	10.1 (9.5–10.6)	5.9 (5.5–6.4)	0.9 (0.7–1.1)
Male	54.4 (53.3–55.4)	51.5 (48.6–54.5)	55.2 (51.4–59)	43 (33.1–52.9)
Race[1]				
White	58.7 (57.5–59.9)	61.1 (57.8–64.4)	78.3 (74.5–82.2)	82.4 (73.1–91.6)
African American	16.7 (15.9–17.8)	16.8 (14.3–19.4)	8.9 (6.3–11.6)	2.9 (0–7.1)
Hispanic	15.4 (14.6–16.3)	13.5 (11.2–15.9)	8.9 (6.3–11.6)	7.4 (1–13.7)
Asian/Indian/Pacific Islander	2.7 (2.3–3.1)	3.4 (2.2–4.6)	1.1 (0.4–2.1)	–
Other/unspecified	6.3 (5.7–6.9)	5.1 (3.6–6.5)	2.7 (1.2–4.2)	7.4 (1–13.7)
Had a complex chronic condition[2]	52.7 (51.6–53.7)	76.5 (74–79.1)	83.8 (80.9–86.7)	79.3 (70.9–87.8)
PIM 2 risk of mortality, median % (IQR)	0.8 (0.3–1.4)	0.9 (0.4–2.2)	1 (0.4–3.2)	1 (0.3–2)
Functional status, median (IQR)[3]				
POPC, preadmission	1 (1–2)	2 (1–3)	3 (1–4)	2 (1–3)
POPC, discharge	2 (1–3)	2 (1–3)	3 (1–4)	2 (1–3)
PCPC, preadmission	1 (1–1)	1 (1–2)	2 (1–3)	1 (1–3)
PCPC, discharge	1 (1–1)	1 (1–3)	2 (1–4)	1 (1–3)

Abbreviations: CI, confidence interval; IQR, interquartile range; PCPC, Pediatric Cerebral Performance Category; PIM, Pediatric Index of Mortality; POPC, Pediatric Overall Performance Category

[1]Based on 7,923 (72%) admissions of patients ≥15 years of age from 46 units that supplied race

[2]Based on 10,481 (96%) admissions of patients ≥15 years of age from 68 units that supplied secondary diagnoses

[3]Based on 3,542 (32%) admissions of patients ≥15 years of age from 21 units that supplied POPC and PCPC scores

Table 2

Admission characteristics and PICU outcomes by age groups

Characteristic, % admissions (95% CI)	15–18 years n=9, 105	19–20 years n=1, 102	21–29 years n=652	≥30 years n=100
Origin				
OR/PACU/procedure suite	33.2 (32.2–34.2)	38.7 (35.9–41.6)	43.3 (39.4–47.1)	60 (50.2–69.8)
Emergency Department	48.8 (47.7–49.8)	32.6 (29.8–35.3)	30.2 (26.7–33.7)	14 (7.1–20.9)
General ward	11.9 (11.2–12.6)	20.1 (17.7–22.4)	16.4 (13.6–19.3)	14 (7.1–20.9)
Another ICU	1.8 (1.5–2.1)	2.7 (1.8–3.7)	2.6 (2.4–3.8)	2 (0–4.8)
Intermediate unit	1.5 (1.2–1.7)	1.6 (0.9–2.4)	1.8 (0.8–2.9)	5 (0.7–9.3)
Chronic/rehab facility	0.3 (0.2–0.4)	0.4 (0–0.7)	1.4 (0.5–2.3)	2 (0–4.8)
Outpatient/Home	2.3 (2–2.6)	3.8 (2.7–4.9)	4.1 (2.6–5.7)	2 (0–4.8)
Other	0.3 (0.1–0.4)	0.1 (0–0.3)	0.2 (0–0.5)	1 (0–3)
Reason for admission[1]				
Respiratory	21.2 (20.3–22.2)	30.6 (27.5–33.6)	36.8 (32.6–40.9)	25.6 (20–32.3)
Neurologic	25.3 (24.3–26.3)	20.8 (18.1–23.5)	17.8 (14.5–21.1)	7.3 (1.6–13.1)
Cardiovascular/shock	14.4 (13.6–15.2)	19.1 (16.5–21.7)	22.6 (19–26.2)	32.9 (22.5–43.3)
Metabolic	13.4 (12.6–14.1)	8 (6.2–9.8)	4.8 (3–6.7)	3.7 (0–7.8)
Hemorrhage/coagulopathy	3.5 (3.1–3.9)	3.2 (2.1–4.4)	2.7 (1.3–4.1	6.1 (0.8–11.4)
Procedure	1 (0.8–1.2)	2.5 (1.5–3.6)	1.9 (0.7–3.1)	–
Other	21.3 (20.3–22.2)	15.7 (13.3–18.2)	13.3 (10.4–16.3)	24.4 (14.9–33.9)
Admitted to PICU with >1000 annual admissions	64.1 (63.1–65)	72.1 (69.5–74.8)	80.4 (77.3–83.4)	90 (84–96)
Unplanned admission	72.6 (71.7–73.5)	67.8 (65–70.5)	63.3 (59.6–67.1)	44 (34.1–53.9)
Pre-/post-operative	37.1 (36.1–38.1)	41.7 (38.7–44.6)	47.7 (43.8–51.5)	60 (50.2–69.8)
Trauma[2]	11.4 (10.6–12.1)	3.5 (2.2–4.7)	2.1 (0.8–3.4)	1.5 (0–4.6)
Used PPV[3]	25 (23.9–26.2)	33 (29.4–36.7)	45.8 (40.6–51)	49 (34.8–63.2)
Disposition				
General ward	66.7 (65.8–67.7)	65.7 (62.9–68.5)	54.1 (50.3–58)	38 (28.3–47.7)
Another ICU	1.2 (1–1.4)	1.8 (1–3.3)	2.1 (1–3.3)	3 (0–6.4)
Intermediate unit	8.6 (8.1–9.2)	9.5 (7.8–11.2)	14 (11.3–16.6)	32 (22.7–41.3)
OR	0.4 (0.3–0.5)	0.4 (0–0.7)	0.2 (0–0.4)	–
Chronic/rehab facility	0.9 (0.7–1.1)	1.2 (0.5–1.8)	2.9 (1.6–4.2)	2 (0–4.8)
Home	16.7 (15.9–17.4)	16.3 (14.1–18.5)	19.6 (16.6–22.7)	18 (10.3–25.7)
Died	2.2 (1.9–2.5)	4 (2.8–5.2)	6.7 (4.8–8.7)	6 (1.3–10.7)
Other	3.2 (2.8–3.6)	1.1 (0.6–1.9)	0.3 (0–1.1)	1 (0–5.4)
PICU LOS, days, median (IQR)	1.4 (0.9–2.9)	1.8 (1–3.9)	2 (1–4.9)	2.1 (1–4.3)
PICU mortality	2.2 (1.9–2.5)	4 (2.8–5.2)	6.7 (4.8–8.7)	6 (1.3–10.7)

Abbreviations: CI, confidence interval; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; OR, operating room; PACU, post-anesthesia care unit; PICU, pediatric intensive care unit; PIM, Pediatric Index of Mortality; PPV, positive pressure ventilation

[1]Based on 8,525 (78%) admissions of patients ≥15 years of age from 49 units that supplied primary reason for admission

[2]Based on 8,831 (81%) admissions of patients ≥15 years of age from 55 units that supplied the trauma variable

[3]Based on 6,443 (59%) admissions of patients ≥15 years of age from 32 units that supplied information on respiratory support

Table 3

Common chronic conditions by age groups

Condition, % admissions (95% CI)*	15–18 years n=8,741	19–20 years n=1,036	21–29 years n=612	≥30 years n=92
Cardiac abnormality, congenital	4.9 (4.4–5.3)	9.6 (7.8–11.3)	15.6 (12.8–18.6)	46.7 (36.3–57.1)
Chromosomal anomaly/genetic abnormality	2.3 (1.9–2.6)	5.2 (3.9–6.6)	6 (4.2–7.9)	4.3 (0.1–8.6)
Gastrointestinal				
Chronic liver disease	0.7 (0.5–0.8)	1.9 (1.1–2.7)	1 (0.2–1.8)	4.3 (0.1–8.6)
Gastrostomy	2.6 (2.3–3)	5.7 (4.3–7.1)	10.8 (8.3–13.2)	8.7 (2.8–14.6)
Other childhood-onset conditions	0.1 (0–0.2)	0.4 (0–0.8)	0.5 (0–1)	–
Hematologic				
Sickle cell anemia	1 (0.8–1.2)	2.1 (1.2–3)	1.1 (0.3–2)	–
Other childhood-onset conditions	0.3 (0.2–0.4)	1.3 (0.6–1.9)	–	–
Immunologic				
Human Immunodeficiency Virus infection	0.2 (0.1–0.2)	0.4 (0–0.8)	–	–
Other childhood-onset conditions	0.1 (0.1–0.2)	0.8 (0.2–1.3)	0.2 (0–0.5)	–
Malignancy				
Bone marrow transplant	1 (0.8–1.2)	1.9 (1.1–2.8)	3.1 (1.7–4.5)	–
Central nervous system	3.4 (3.1–3.8)	4.2 (2.9–5.4)	6.7 (4.7–8.7)	–
Hemopoietic/lymphatic	3.5 (3.1–3.9)	6.1 (4.6–7.5)	6.4 (4.4–8.3)	–
Solid tumor, non-CNS	3.7 (3.2–4.1)	5.9 (4.5–7.3)	4.1 (2.5–5.7)	4.3 (0.1–8.6)
Metabolic/endocrine				
Diabetes mellitus, insulin dependent	3.7 (3.3–4.1)	2.9 (1.9–3.9)	2.3 (1.1–3.4)	–
Other childhood-onset conditions	2.1 (1.8–2.4)	4.4 (3.2–5.7)	4.9 (3.2–6.6)	5.4 (0.7–10.2)
Neurologic/neurodevelopmental/neuromuscular				
Cerebral palsy	4.1 (3.6–4.5)	7.8 (6.2–9.5)	10.3 (7.9–12.7)	6.5 (1.4–11.7)
Cerebral structural abnormality, congenital	2.4 (2–2.7)	2.8 (1.8–3.8)	4.2 (2.6–5.9)	1.1 (0–3.2)
Developmental delay, general ized/hypoxic ischemic encephalopathy	4.9 (4.4–5.3)	9.1 (7.3–10.8)	13.6 (10.8–16.3)	15.2 (7.7–22.7)
Developmental delay, specific/autism	3.3 (2.9–3.7)	6 (4.5–7.4)	5.4 (3.6–7.2)	6.5 (1.4–11.7)
Epilepsy	7.6 (7.1–8.2)	12 (10–13.9)	16.8 (13.9–19.8)	13 (6–20.1)
Hydrocephalus	4.2 (3.8–4.6)	5.9 (4.5–7.3)	8.3 (6.1–10.5)	5.4 (0.7–10.2)
Muscular dystrophy	1.6 (1.3–1.9)	3.1 (2–4.1)	3.9 (2.4–5.5)	–
Spina bifida/congenital spinal cord abnormality	1 (0.8–1.2)	2.2 (1.3–3.1)	4.1 (2.5–5.7)	2.2 (0–5.2)
Renal/genitourinary				
Chronic renal failure/dialysis dependence	2.2 (1.9–2.5)	6.2 (4.7–7.6)	4.1 (2.5–5.7)	5.4 (0.7–10.2)
Other childhood-onset conditions	1.1 (0.9–1.3)	2.9 (1.9–3.9)	2.5 (1.2–3.7)	1.1 (0–3.2)
Respiratory				
Asthma	6.8 (6.3–7.4)	5 (3.7–6.4)	5.9 (4–7.8)	4.3 (0.1–8.6)
Chronic invasive ventilation	1.1 (0.9–1.3)	2.9 (2–4.1)	5.4 (3.8–7.4)	1 (0–5.4)
Cystic fibrosis	0.7 (0.6–0.9)	1.6 (0.9–2.4)	2 (0.9–3.1)	6.5 (1.4–11.7)
Tracheostomy	3.2 (2.8–3.6)	7 (5.3–8.7)	13.7 (10.8–16.6)	6.5 (1.4–11.7)
Other childhood-onset conditions	1.2 (1–1.5)	3 (2–4)	2.1 (1–3.3)	–

Condition, % admissions (95% CI)*	15–18 years n=8,741	19–20 years n=1,036	21–29 years n=612	≥30 years n=92
Spine curvature conditions	9.6 (9–10.3)	12.5 (10.4–14.5)	12.3 (9.6–14.9)	8.7 (2.8–14.6)

Abbreviations: CNS, central nervous system; CI, confidence interval

*Based on 10,481 (96%) admissions of patients ≥15 years of age from 68 units that supplied secondary diagnoses

Table 4

Common acute conditions by age groups

Condition, % admissions (95% CI)*	15–18 years n=8,741	19–20 years n=1,036	21–29 years n=612	≥30 years n=92
Cardiac				
Arrhythmia	6 (5.5–6.5)	5.8 (4.4–7.2)	13.4 (10.7–16.1)	21.7 (13.2–30.3)
Congestive heart failure	0.9 (0.7–1.1)	3.3 (2.2–4.4)	3.9 (2.4–5.5)	7.6 (2.1–13.1)
Shock	3.8 (3.4–4.3)	5.2 (3.9–6.6)	5.2 (3.5–7)	7.6 (2.1–13.1)
Gastrointestinal hemorrhage	1.4 (1.2–1.7)	1.4 (0.6–2.1)	2.1 (1–3.3)	2.2 (0–5.2)
Ketoacidosis	9.8 (9.2–10.4)	5.4 (4–6.8)	0.8 (0.1–1.5)	3.3 (0–7)
MODS/SIRS	0.3 (0.2–0.5)	0.8 (0.2–1.3)	1.1 (0.3–2)	2.2 (0–5.2)
Neurologic				
Altered mental status/encephalopathy	7.6 (7–8.1)	7.4 (5.8–9)	4.6 (2.9–6.2)	7.6 (2.1–13.1)
Seizure	4.9 (4.5–5.4)	6.4 (4.9–7.9)	6.4 (4.4–8.3)	4.3 (0.1–8.6)
Poisoning	9.3 (8.7–9.9)	1.8 (1–2.7)	0.8 (0.1–1.5)	–
Renal				
Acute renal failure	2.7 (2.3–3)	4.1 (2.9–5.3)	4.4 (2.8–6)	6.5 (1.4–11.7)
Pyelonephritis/cystitis	1.2 (1–1.4)	1.5 (0.8–2.3)	1.8 (0.7–2.9)	5.4 (0.7–10.2)
Respiratory				
Acute lung injury/ARDS/respiratory failure	11.8 (11.1–12.5)	15.3 (13.1–17.5)	24.8 (21.4–28.3)	19.6 (11.3–27.8)
Pneumonia/pneumonitis	5.4 (5–5.9)	7.6 (6–9.2)	10.1 (7.7–12.5)	14.1 (6.9–21.4)
Status asthmaticus	2.5 (2.2–2.8)	1.4 (0.7–2.2)	1.1 (0.3–2)	1.1 (0–3.2)
Septicemia/bacteremia/viremia	3.5 (3.1–3.9)	7 (5.5–8.6)	5.1 (3.3–6.8)	5.4 (0.7–10.2)

Abbreviations: ARDS, acute respiratory distress syndrome; CSF, cerebral spinal fluid; CI, confidence interval; MODS, Multiple Organ Dysfunction Syndrome; SIRS, Systemic Inflammatory Response Syndrome

*Percentages based on 10,481 (96%) admissions of patients ≥15 years of age from 68 units that supplied secondary diagnoses

Table 5

Procedures and operations by age groups

Condition, % admissions (95% CI)*	15–18 years n=5,814	19–20 years n=741	21–29 years n=384	≥30 years n=50
Cardiothoracic				
Assistive device/pacemaker	4.6 (2.9–6.3)	0.2 (0–0.6)	3.4 (1.6–5.2)	10 (1.4–18.6)
Cardiac	3.7 (3.2–4.1)	5.1 (3.5–6.7)	10.2 (7.1–13.2)	32 (18.6–5.4)
Catheterization, therapeutic/diagnostic	2.1 (1.7–2.5)	2.3 (1.2–3.4)	2.1 (0.6–3.5)	2 (0–6)
Thoracic	2.8 (2.3–3.2)	3.8 (2.4–5.2)	3.6 (1.8–5.5)	4 (0–9.6)
Gastrointestinal				
Gastrostomy	0.7 (0.4–0.9)	0.1 (0.2–1.6)	1.6 (0.3–2.8)	2 (0–6)
Other	4.6 (4–5.1)	7 (5.2–8.9)	6.8 (4.2–9.3)	10 (1.4–18.6)
Genitourinary	1.4 (1.1–1.7)	2.6 (1.4–3.7)	1 (0.2–2.1)	8 (0.2–15.8)
Neurologic				
Craniotomy/craniectomy	5.9 (5.3–6.5)	4.6 ((3.1–6.1)	6.3 (3.8–8.7)	–
CSF shunt	1.3 (1–1.6)	1.9 (0.9–2.9)	3.6 (1.8–5.5)	2 (0–6)
Other	5.1 (4.5–5.6)	3.8 (2.4–5.2)	4.1 (2.2–6.2)	–
Orthopedic				
Spinal fusion	7.4 (6.8–8.1)	5.8 (4.1–7.5)	1.6 (0.3–2.8)	–
Other	3 (2.6–3.4)	2.7 (1.5–3.9)	1.3 (0.2–2.4)	–
Otolaryngologic				
Tracheotomy	1 (0.7–1.2)	1.3 (0.5–2.2)	2.3 (0.8–3.9)	2 (0–6)
Other	2.1 (1.7–2.4)	2.3 (1.2–3.4)	3.8 (1.6–5.2)	4 (0–9.6)
Vascular	0.7 (0.5–0.9)	0.5 (0–1.1)	1 (0–2.1)	–

Abbreviations: CSF, cerebral spinal fluid; CI, confidence interval

*Percentages based on 6989 (64%) admissions of patients ≥15 years of age from 44 units that supplied procedures.