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The Burden of Pediatric Neurocritical Care in the United States

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Abstract

Background: Pediatric Neurocritical Care (PNCC) diseases affect thousands of children annually. We aimed to quantify the burden of PNCC through generation of national estimates of disease incidence, utilization of critical care interventions (CCI), and hospital outcomes.

Methods: We performed a retrospective cohort analysis of the Kids Inpatient Database over three years to evaluate pediatric traumatic brain injury, neuro-infection or inflammatory diseases, status epilepticus, stroke, hypoxic ischemic injury after cardiac arrest, and spinal cord injury. We evaluated use of CCI, death, length of stay, hospital charges, and poor functional outcome defined as receipt of tracheostomy or gastrostomy or discharge to a medical care facility.

Results: At least one CCI was recorded in 67,058 (23%) children with a primary neurologic diagnosis, and considered a PNCC admission. Over half of PNCC admissions had at least one chronic condition, and 23% were treated in children's hospitals. Mechanical ventilation was the most common CCI, but utilization of CCIs varied significantly by diagnosis. Among PNCC admissions, 8,110 (12%) children died during hospitalization and 14,067 (21%) children had poor functional outcomes. PNCC admissions accounted for over 1.5 million hospital days and over \$4 billion in hospital costs cumulatively in the study years. Most PNCC admissions, across all diagnoses, had prolonged hospitalizations >1 week with an average cost of \$39.9 thousand per admission.

Conclusion: This large, nationally representative study shows PNCC diseases are a significant public health burden with substantial risk to children's health. More research is needed to improve outcomes in these vulnerable children.

Keywords

Pediatric; critical care; neurology; traumatic brain injury; stroke

Introduction

Neurologic diseases affect thousands of children annually, account for 20–25% of pediatric critical care admissions, [1–3] and are leading causes of pediatric morbidity and mortality.[1, 4–8] Neurologic diagnoses that commonly require pediatric critical care hospitalization include traumatic brain injury (TBI), neuro-infections and inflammatory disease, status epilepticus, stroke, hypoxic ischemic injury after cardiopulmonary arrest, and spinal cord injury. [1] Some of these Pediatric Neurocritical Care (PNCC) diagnoses, such as TBI and hypoxic ischemic injury, have been associated with high mortality and survivors are at risk for substantial morbidity including physical disability, neurocognitive impairment, and psychosocial dysfunction.[9–18] These morbidities lead to significant impairment in quality of life and increased healthcare costs over time.[12, 19–26]

Research is limited in the PNCC population in a variety of areas including treatments, outcomes, and healthcare utilization.[1, 3, 6, 7, 27–31] We aimed to provide a better understanding of the scope of PNCC admissions utilizing the Kids' Inpatient Database (KID) to generate a nationally representative sample of pediatric hospitalizations over three years. We evaluated incidence of primary neurologic diagnoses requiring PNCC and evaluated receipt of different CCI among PNCC diagnoses. We additionally evaluated death and hospital outcomes in PNCC to quantify the public health burden of this important subset of pediatric disease.

Methods

Study Design

We performed a retrospective cohort analysis of administrative data within the most recent versions (2006, 2009, and 2012) of the Kids Inpatient Database (KID) from the Agency of Healthcare Research and Quality.[32] The KID contains pediatric discharges for children ages 20 years and younger in the United States (US) and a large proportion of all hospitals caring for pediatric patients nationally. The KID is de-identified and published in three year intervals. The KID uses a stratified probability sampling design, sampling 80% of all pediatric discharges from >3700 hospitals in each of the study years, which allows for national estimates of all pediatric hospital discharges using weighting procedures. The KID includes demographic information, payer, hospital characteristics, ICD-9-CM diagnosis codes, ICD-9-CM procedure codes, clinical classification software (CCS) codes that group ICD-9-CM diagnosis and procedure codes, chronic condition indicators, length of stay, hospital charges, discharge status, and in-hospital death. Hospital characteristics found in KID include children's hospital status and hospital region defined by the Census Bureau. To preserve patient and hospital data anonymity, the KID data use agreement prohibits the reporting of variables with counts ≤ 10 . Use of the KID is considered non-human subjects research and is not subject to Oregon Health and Science University's Institutional Review Board evaluation.

Population Definitions

We identified pediatric admissions with ICD-9-CM diagnosis codes and CCS codes for neurologic diagnoses including TBI, neuro-infections and inflammatory diseases (including meningitis, encephalitis, and abscess), stroke (hemorrhagic and ischemic), status epilepticus, hypoxic ischemic injury following cardiopulmonary arrest, and spinal cord injury (See supplementary table for specific codes). We defined a primary neurological admission as an admission with one of the diagnosis codes of interest within the first and second diagnosis fields (KID contains up to 25 separate ICD-9-CM diagnosis codes per admission). If admissions had more than one code of interest (0.8% of admissions with a neurologic diagnosis) in the first and second fields, they were classified by the code occupying the first diagnosis field (ie admissions were classified as infectious/inflammatory when meningitis occupied the first field and status epilepticus occupied the second field). We included children of all ages, but admissions identified as neonatal admissions by the KID variable were excluded. Admissions for neurosurgical interventions without one of the identified neurologic diagnoses of interest were excluded.

PNCC patients were defined as those receiving a CCI during admission. Receipt of a CCI was identified with ICD-9-CM procedure codes or CCS codes for procedures or medications that require critical care admission. CCI was defined as the presence of codes for intubation and mechanical ventilation, central venous catheterization (CVC), arterial line placement, intracranial pressure (ICP) monitoring, neurosurgical interventions (including craniectomy, hematoma or abscess evacuation, elevation of skull fracture), non-invasive ventilation, extracorporeal support, or vasopressor infusions. Acute stroke therapies including tissue plasminogen activator (TPA) or endovascular therapy were considered CCI among stroke patients only. Non-invasive ventilation, extracorporeal support, and vasopressor infusions were reported as part of overall CCI, but due to low numbers were not reported individually per the KID data use agreement. Where able, codes were chosen based on prior reports utilizing administrative data for neurologic diagnoses and critical care interventions.[33–38] A complete list of codes used for study definitions can be found in the supplementary table. Demographic and clinical characteristics provided by KID variables were evaluated by groups based on receipt of CCI. Hospital mortality was evaluated as identified in KID. We created a composite outcome to define poor functional outcome as need for tracheostomy or gastrostomy during hospitalization or discharge to a medical care facility (nursing or rehabilitation facility), consistent with prior studies.[33, 39] Additionally, a prior report in pediatric TBI showed that tracheostomy or gastrostomy placement was analogous to worse Functional Status Scale score at discharge.[40] The codes we used are specifically for placement of new tracheostomy or gastrostomy devices and do not include codes associated with complications from those devices, adjustment or revision, or prior history of the devices. Hospital charges were converted to costs with the supplementary files provided by KID. Variable details and definitions provided by KID and quality control procedures can be found online (<https://www.hcup-us.ahrq.gov/kidoverview.jsp>).[32]

Statistical Analysis

Demographic and admission characteristics of the analytic sample were summarized using descriptive statistics. United States Census Bureau (www.census.gov) estimates were used to

calculate incidence based on population estimates in 2006, 2009, and 2012. Weighted estimates were generated and reported as rounded whole numbers and percentages or means with standard error (SE). Differences in these statistics by receipt of CCI were assessed using chi-squared tests for categorical variables and ANOVA for continuous variables. Univariate logistic regression was used to assess odds of death and poor functional outcome by number of CCIs and study year for each diagnosis. Results of logistic regression are reported as Odds Ratio (OR) and 95% Confidence Interval (CI). A Bonferroni adjustment was made to account for multiple tests defining significance at $p < .008$. All analysis was performed in SAS 9.1 (Cary, NC) using appropriate survey weighting procedures as provided by KID.[32]

Results

Weighted estimates identified a total of 286,105 children with a primary neurologic diagnosis in the three years evaluated. At least one CCI was recorded in 67,058 (23%) children with a primary neurologic diagnosis, and 23,936 (8%) children received two or more CCIs. The overall incidence of PNCC admissions (those receiving at least one CCI) averaged 26.9 per 100,000 US children per year. Table 1 compares demographic and clinical characteristics of primary neurological admissions by receipt of a CCI. Males accounted for nearly 2/3 of all primary neurologic admissions, and similar proportions of males among CCI groups were found. Most PNCC admissions had at least one chronic condition identified. A chronic condition was identified in 86% of PNCC patients receiving 2 CCI compared to only 47% of patients without CCI ($p < .001$). Chronic conditions were identified more frequently in PNCC admissions across all diagnoses compared to admissions without at CCI ($p < .001$), though prevalence of chronic conditions varied by diagnosis. Most patients were not treated at children's hospitals, regardless of CCI status. Among PNCC admissions, frequency of admission to a children's hospital varied with diagnoses from 10–38%, and was lowest in traumatic injuries (TBI= 15%, spinal cord = 10%).

Among PNCC admissions (those receiving at least one CCI), TBI ($n=36,828$; 55%) was the most common diagnosis, followed by neuro-infection and inflammatory disease ($n=10,648$; 16%), status epilepticus ($n=9,047$; 14%), stroke ($n=5,849$; 9%), hypoxic ischemic injury ($n=3,142$; 5%), and spinal cord injury ($n=1,542$; 2%). While TBI and neuro-infection and inflammatory diseases were most common overall, those diagnoses had the lowest proportion of admissions receiving CCI. Figure 1 presents incidence of admissions overall, incidence of PNCC admissions receiving CCI, and proportion of overall neurologic admissions receiving CCI by diagnosis and study year. The annual incidence of all TBI admissions decreased by 25% ($p < .001$), and the incidence of all neuro-infection and inflammation diagnoses decreased 31% from 2006 to 2012 ($p < .001$). Incidence of all status epilepticus admissions increased 24% ($p < .001$), and incidence of all stroke admissions increased 16% from 2006 to 2012 ($p < .001$). The proportion with hypoxic ischemic injury receiving CCI significantly decreased over the three study years ($p < .001$), but the proportion receiving CCI was statistically similar each year in other diagnoses.

Among PNCC admissions (those receiving at least one CCI), the proportion of patients receiving multiple CCIs and the type of CCI varied with diagnosis (Table 2). More than one

third (36%) of the PNCC admissions recorded 2 or more CCI, ranging from 20–44% by diagnosis. Intubation and mechanical ventilation was the most common CCI overall, but the proportion of PNCC patients receiving this CCI ranged from 28–93% across specific diagnoses. Prolonged mechanical ventilation >96 hours was common in PNCC admissions, ranging from 11–46% by diagnosis. ICP monitors were common in PNCC admissions with TBI (17%), and ICP monitoring occurred in 40% of TBI patients with concurrent prolonged mechanical ventilation >96hours. Only 4% of all PNCC TBI admissions and 14% of PNCC TBI admissions with concurrent prolonged mechanical ventilation >96hours had both an ICP monitor and arterial catheter. Neurosurgical intervention was recorded in nearly one third of PNCC patients with TBI or stroke. TPA or endovascular therapy was recorded in 2% of ischemic stroke patients. Hemorrhagic stroke accounted for most of the stroke patients receiving any CCI (n=4194, 72%) and nearly all of the PNCC stroke patients receiving ICP monitoring (n=1562, 90%) and neurosurgical intervention (n=1544, 86%).

High rates of death were seen in PNCC admissions (those receiving at least one CCI). In the three study years, 8,110 (12%) PNCC children died during hospitalization (compared to 0.2% of primary neurologic diagnoses without a CCI and 0.4% of all KID admissions in the study years). Increasing numbers of CCIs were significantly associated with increased odds of mortality in all diagnoses (all $p<.001$). Table 3 details outcomes in the PNCC population (those receiving at least one CCI), and rates of death varied by diagnosis. Mortality was high in hypoxic ischemic injury (39%), though odds of mortality significantly decreased in 2012 compared to 2006 (OR 0.56, 95% CI 0.42–0.73). Mortality in PNCC admissions was also substantial with a diagnosis of TBI or stroke (14% each), spinal cord injury (7%), neuro-infection and inflammation (4%), and status epilepticus (3%), and odds of mortality was similar across study years for these diagnoses. Hemorrhagic stroke accounted for 73% (n=595) of all PNCC stroke deaths.

Among all PNCC admissions (those receiving at least one CCI), 1 in 5 (21%) children had poor functional outcome, defined as receiving a tracheostomy (n=4,650; 7%) or gastrostomy (n=5,123; 8%) or discharge to a medical care facility (n=11,376; 17%), compared to 1% with poor functional outcome among all KID admissions in the study years. Rates of poor functional outcome varied with PNCC diagnosis (Table 3). Most PNCC survivors of spinal cord injury (71%) had poor functional outcome, including 20% requiring tracheostomy and 61% discharged to a medical care facility. Poor functional outcome was also common in TBI (26%), hypoxic ischemic injury (22%), and stroke (20%). PNCC patients with neuro-infection and inflammation (10%) and status epilepticus (5%) had lower rates of poor functional outcome. Odds of poor functional outcome increased from 2006 to 2012 for neuro-infection and inflammation (OR 1.7, 95% CI 1.3–2.1), but were similar across years in other diagnoses.

Compared to neurologic admissions without a CCI, PNCC admissions had significantly longer average length of stay (11.6 versus 3.4 days, $p<.001$) and higher average hospital costs (\$39.9 versus \$8.7 thousand, $p<.001$) per admission. The small population of PNCC admissions (n=67,058) accounted for over 1.5 million hospital days and over \$4.4 billion in hospital costs cumulatively in the three study years. Most PNCC admissions, across all

diagnoses, had prolonged hospitalizations >1 week with an average cost of \$39.9 thousand per admission (Table 3).

Discussion

PNCC diseases are a significant public health burden with substantial risk to children's health. This large, nationally representative sample shows pediatric admissions with a primary neurologic diagnosis frequently require at least one CCI (23%). These PNCC admissions include individually rare diagnoses, but as a group are associated with high rates of hospital death (12%) and poor functional outcome at discharge (21%). The small subset of pediatric patients receiving PNCC has prolonged hospital length of stay, generates billions of dollars in hospital costs, and utilizes a substantial amount of healthcare resources through critical care procedures and highly specialized care during hospitalization. High rates of discharges to care facilities also highlight the substantial disabilities seen in survivors that require ongoing medical care after hospitalization. More research for these conditions is needed to quantify longitudinal outcomes and long-term disease burden, and to identify interventions to improve outcomes.

The population of PNCC patients we identified had a changing disease incidence over study years and several important demographic characteristics to consider. Incidence of TBI and neuro-infection and inflammatory disease decreased significantly while incidence of stroke and status epilepticus increased significantly among hospitalized children. The overall and declining incidence of TBI hospitalizations we found is similar to other studies and Centers for Disease Control (CDC) reports.[8, 41] The decline in TBI related hospitalizations has been attributed to reductions in motor vehicle accidents and targeted injury prevention campaigns, such as increasing proper use of helmets and child restraints in motor vehicles. [8, 41, 42] Similarly, the CDC has reported declining incidence over the reported study years of meningitis for several pathogens, such as *Meningococcus* and *Haemophilus Influenzae*, [43] and may contribute to the declining incidence of neuro-infection and inflammatory disease we found. Studies evaluating pediatric stroke have reported wide ranges of incidence from 0.6–7.9 per 100,000 children per year, though the more recent literature has suggested an increase in incidence with higher incidence reported in later study years.[33] The overall incidence of status epilepticus we found was less than previous reports for all patients with status epilepticus. Our findings are similar to incidence estimates when excluding neonatal patients and those with status epilepticus secondary to another neurologic disease process like meningitis or stroke, and our incidence estimate closely approximates prior findings in status epilepticus due to underlying epilepsy or non-specific illnesses resulting in prolonged febrile seizures as the primary diagnosis.[44] The increasing incidence of status epilepticus we found may be related to the change in definition to include any seizure over 5 minutes in recent years.[45] Our rates of HIE are lower than those reported for all cases of pediatric out-of-hospital cardiac arrest (8.3 per 100,000 children per year),[46] though our exclusion of neonatal admissions, inclusion of only primary diagnosis codes, and analysis of only those patients admitted to a hospital (rather than those who died prior to admission) likely accounts for much of this difference. The changing disease characteristics of the PNCC population should be investigated further among specific diseases to determine driving factors.

The majority of PNCC admissions had chronic conditions identified by KID, but detailed assessment of chronic conditions was beyond the scope of this study. KID identifies a range of chronic conditions that likely have variable impact on outcomes and risk of PNCC hospitalization, including attention deficit disorder, asthma, genetic disorders, and epilepsy. [32] Children with complex chronic conditions are known to require more complicated care and have worse outcomes.[47] While diagnoses such as stroke or status epilepticus are frequently associated with underlying conditions,[33, 48–50] patients with traumatic injuries are frequently healthy prior to admission.[40] Children with chronic conditions accounted for a disproportionate number of PNCC admissions across all diagnoses in this study, and this may account in part for the high rates of death and morbidity among PNCC admissions. Despite high rates of chronic conditions, most PNCC patients were not treated at a children's hospital consistent with previous reports.[1] Children with TBI have been reported to have better outcomes when treated at a children's hospital,[51] and the effect of treatment at a children's hospital on outcome should be investigated further for other PNCC populations. Several disease and patient specific factors contribute to risk for poor outcomes that are not well evaluated with administrative data. The specialized care required for children with a PNCC diagnosis and those with complex chronic conditions may be better provided at hospitals with available pediatric subspecialists. Specialized PNCC teams are available at some institutions, but PNCC remains a new subspecialty with unknown effects of these teams on patient outcomes.

Our study is the first to report distribution of CCIs among many PNCC diagnoses. Our study found that intubation and mechanical ventilation was most common among all diagnoses, but use of different CCI varied substantially across diagnoses. In studies evaluating TBI, critical care utilization varies by the populations evaluated and substantial variation has been found between hospitals.[35, 39, 52] TBI studies of moderate to severe injury have reported intubation in 12–93%[34, 40, 53], ICP monitors in 8%–55%[34, 39, 52, 54], and neurosurgical intervention in 28–40%.[34, 55] Differences in TBI study populations, hospital practices, and methods make direct comparison difficult, though our study adds to data showing lack of adherence to the Brain Trauma Foundation guidelines for ICP monitoring in severe TBI.[56] Among ischemic stroke studies, previous reports have suggested 43% of admissions require a CCI,[33] including 2% with TPA and 1% with endovascular therapy,[33, 57] all consistent with our findings. One prior study among patients with meningitis requiring critical care reported use of ICP monitors in 7%.[35] consistent with our findings in PNCC admissions with neuro-infection and inflammatory disease.

Among PNCC admissions, hospital mortality and poor functional outcome were common and similar to findings in prior studies of neurologic diagnoses with different methodologies. Patients with hypoxic ischemic injury, TBI, and stroke requiring CCI had the highest mortality in our study, well above 10% for each diagnosis and consistent with prior reports. [7, 33, 38, 40, 50, 58, 59] The decline in mortality seen in hypoxic ischemic injury patients in our study coincided with a decline in the proportion of hospitalized patients receiving CCI with this diagnosis from 2006 to 2012. Prior studies have shown conflicting results on survival trends after out-of-hospital cardiac arrest, though much of the survival difference is attributed to age, pre-hospital care, and regional variation.[46, 59] Mortality was lower in

other PNCC diagnoses receiving CCI in our study, but remained high compared to the reported 2–5% for all pediatric critical care admissions in recent studies, was similar to other reports, and highlights the substantial impact of PNCC diagnoses on child health.[6, 44, 60] As expected, mortality was well below 1% among neurologic diagnoses not receiving one of the CCIs we used to define the PNCC population in our study, suggesting our definition captured the majority of critically ill children with a primary neurologic diagnosis of interest.

High rates of poor functional outcome in our study after PNCC hospitalization highlight the ongoing need for medical care among survivors, including discharge to medical and rehabilitation facilities and medical equipment. We found similar rates for poor functional outcome as other studies in pediatric TBI and stroke evaluating functional outcomes, neurologic disabilities, and rehabilitation needs.[33, 39, 40, 58] Poor functional status is a known risk factor for impaired quality of life and medical needs increase readmissions and healthcare costs over time.[22, 26, 61] More research is needed to improve hospital outcomes in this population and to identify the healthcare burden, both through longitudinal assessment of outcomes and medical system impact of PNCC patients after discharge.

Our study showed PNCC patients create a substantial burden on the healthcare system in terms of length of stay and hospital charges, and underestimates the true PNCC burden as we did not include children who are admitted to critical care units only for observation due to their risk for deterioration. We chose to focus on the subset of children with a primary neurologic diagnosis receiving PNCC, underestimating the true burden of neurologic diagnoses in pediatric critical care by excluding those with a neurologic complication of another acute illness or with a chronic neurologic illness such as hydrocephalus or tumor. We found hundreds of thousands of hospital days and billions of dollars in hospital costs are generated by this small population of PNCC patients requiring CCI every year. Even though these diseases are individually rare, the substantial impact on hospital resources highlights the need for further research in this population.

This study is limited by use of administrative data, where completeness and accuracy of coding cannot be assured. The accuracy of many of the ICD-9-CM codes we used are unknown, but where able we used codes to define variables consistent with reported literature with the highest accuracy. Studies in pediatric stroke have reported positive predictive values of 77–84% for the codes we used.[33, 36, 37] TBI codes we used have high sensitivity (96%),[34] and the codes we used are utilized by the CDC to monitor TBI.[8] Variability is reported in codes identifying CCI, with high accuracy values in codes for ICP monitors (98%) and neurosurgical intervention (94%), but lower accuracy with codes for mechanical ventilation (80%), CVC (79%), and arterial line placement (79%).[34] The imperfect accuracy of administrative data should be considered when interpreting the results. The large sample size, high sampling frequency, and weighted estimates generated by the KID yield a nationally representative sample that may mitigate some of the challenges associated with administrative data including code accuracy and reporting variability between hospitals. Additionally, given variability in hospital practice, some procedures we considered CCI, such as non-invasive ventilation and ICP monitoring, could have been provided outside critical care units, though unlikely in acute PNCC diagnoses. Weighting

procedures with the KID generate results similar to other research methods for a variety of pediatric diseases evaluating incidence and utilization,[62–64] including this study, and are valuable for evaluating rare diseases and procedures.[32] KID is de-identified, limiting granularity of data, including demographic, clinical, and diagnostic details that could be used for further analyses or data confirmation.

Conclusion

PNCC admissions include individually rare diseases, but account for substantial morbidity and mortality among hospitalized children. PNCC admissions utilize critical care resources through CCI and specialized care, have prolonged hospitalizations, and generate billions of dollars in hospital costs. Many of these children require ongoing care after discharge, furthering the burden of PNCC. Future research should quantify longitudinal outcomes, evaluate the long-term burden of PNCC on healthcare systems, and identify effective interventions to improve outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1:

Incidence of primary neurologic admissions and proportion receiving critical care intervention for each diagnosis by year in the United States

CCI=Critical Care Intervention; chart shows incidence of admissions per 100,000 United States children per year (bars, leftward y-axis) and percent of total admissions requiring critical care intervention (rightward y-axis) by diagnosis and study year (x-axis). Total height of light gray bars represents total admissions with a primary neurologic diagnosis with dark gray bars showing incidence of admissions receiving critical care intervention. Percent markers represent percent of all primary neurologic admissions within each diagnosis by study year.

Table 1.

Demographic and admission characteristics for primary neurologic admissions with and without receipt of critical care interventions

	No CCI N=219,048 (%)	One CCI N= 43,122 (%)	Two or More CCI N=23,936 (%)
Average Incidence all diagnoses per 100,000 children per year	88.0	17.3	9.6
Average Age (SE)	10.3 (0.1)	10.3 (0.1)	11.0 (0.2)
Female Gender	77,579 (36%)	15,056 (35%)	8,195 (34%)
Race/Ethnicity			
White	98,649 (54%)	19,265 (54%)	10,572 (53%)
African American	29,296 (16%)	5,921 (17%)	3,432 (17%)
Hispanic	37,437 (21%)	6,977 (20%)	3,991 (20%)
Other	15,681 (9%)	3,414 (10%)	2,047 (10%)
Payer/Insurance			
Government	83,207 (38%)	17,409 (40%)	9,682 (41%)
Private	106,798 (49%)	19,921 (46%)	10,872 (46%)
Other	28,613 (13%)	5,689 (13%)	3,314 (14%)
Chronic conditions			
None	115,947 (53%)	12,619 (29%)	3,252 (14%)
One or More	103,100 (47%)	30,503 (71%)	20,684 (86%)
Children's Hospital	44,050 (20%)	10,500 (24%)	5,150 (22%)
Hospital Region			
Northeast	40,681 (19%)	6,869 (16%)	3,400 (14%)
Midwest	45,497 (21%)	9,558 (22%)	5,759 (24%)
South	79,117 (36%)	16,504 (38%)	9,073 (38%)
West	53,752 (25%)	10,191 (24%)	5,704 (24%)

CCI: Critical Care Intervention, SE: Standard error of the mean. Numbers presented are weighted estimates rounded to whole numbers and percents and may not sum to totals.

Table 2.

Incidence and distribution of critical care interventions among Pediatric Neurocritical Care admissions

Intervention	Traumatic Brain Injury N=36,828 (%)	Infection/ Inflammation N=10,648 (%)	Status Epilepticus N=9,048 (%)	Stroke N=5,850 (%)	Hypoxic Ischemic N=3,141 (%)	Spinal Cord Injury N=1,542 (%)
Average incidence per 100,000 children per year	14.8	4.3	3.6	2.4	1.3	0.6
One CCI	22,205 (60%)	7,696 (72%)	7,247 (80%)	3,272 (56%)	1,745 (56%)	956 (62%)
Two or more CCI	14,624 (40%)	2,952 (28%)	1,800 (20%)	2,577 (44%)	1,397 (44%)	586 (38%)
Intubation	27,776 (75%)	2,979 (28%)	8,386 (93%)	2,808 (48%)	2,518 (80%)	1,130 (73%)
>96 hours	8,866 (24%)	1,127 (11%)	1,132 (13%)	1,214 (21%)	1,172 (37%)	713 (46%)
ICP monitor	6,132 (17%)	1137 (11%)	79 (1%)	1,728 (30%)	75 (2%)	37 (2%)
CVC	9,749 (26%)	8,152 (77%)	1,747 (19%)	2,232 (38%)	1,342 (43%)	653 (42%)
Arterial line	5,516 (15%)	688 (6%)	578 (6%)	1,025 (18%)	733 (23%)	339 (22%)
Neurosurgery	10,931 (30%)	1,329 (12%)	79 (1%)	1,795 (31%)	235 (7%)	51 (3%)

CCI: Critical Care Intervention; ICP: Intracranial Pressure; CVC: Central venous catheterization; Numbers presented are weighted estimates rounded to whole numbers and percents, and may not sum to totals

Table 3.

Hospital outcomes among Pediatric Neurocritical Care diagnoses

Outcome	Traumatic Brain Injury N=36,828 (%)	Infection/ Inflammation N=10,648 (%)	Status Epilepticus N=9,048 (%)	Stroke N=5,850 (%)	Hypoxic Ischemic N=3,141 (%)	Spinal Cord Injury N=1,542 (%)
Death	5,310 (14%)	432 (4%)	229 (3%)	819 (14%)	1,218 (39%)	102 (7%)
Poor functional outcome	9,520 (26%)	1,108 (10%)	473 (5%)	1,182 (20%)	694 (22%)	1,089 (71%)
Gastrostomy	3,785 (10%)	244 (2%)	106 (1%)	249 (4%)	199 (6%)	541 (35%)
Tracheostomy	3,183 (9%)	355 (3%)	202 (2%)	319 (5%)	289 (9%)	302 (20%)
Care facility discharge	7,845 (21%)	854 (8%)	283 (3%)	975 (17%)	477 (15%)	941 (61%)
Average length of stay in days (SE)	10.3 (0.2)	15.1 (0.4)	7.0 (0.2)	16.2 (0.4)	12.8 (0.7)	24.6 (1.0)
Cumulative hospital days						
2006	280,230	130,806	31,713	44,946	29,498	29,217
2009	239,852	129,939	38,650	56,465	28,713	27,279
2012	205,484	108,383	39,146	54,265	26,157	23,057
Average cost per hospitalization in <i>thousand</i> dollars (SE)	37.6 (0.6)	41.3 (1.2)	22.8 (0.9)	64.1 (2.1)	38.6 (1.5)	95.3 (3.8)
Cumulative cost in <i>million</i> dollars						
2006	845.1	237.6	74.2	127.3	67.6	87.7
2009	743.4	268.3	99.8	180.4	60.8	86.8
2012	770.1	283.5	129.8	222.0	73.4	91.8

SE: Standard error of the mean; Poor functional outcome defined as either receipt of tracheostomy, receipt of gastrostomy, or discharge to a nursing or rehabilitation facility. Numbers presented are weighted estimates rounded to whole numbers and percents and may not sum to totals.