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Hospitalizations of children with neurological disorders in the United States

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Abstract

Objective—Although neurologic disorders are among the most serious acute pediatric illnesses, epidemiologic data are scarce. We sought to determine the scope and outcomes of children with these disorders in the US.

Design—Retrospective cohort study

Setting—All non-federal hospitals in 11 states encompassing 38% of the US pediatric population.

Patients—Children 29 days-19 years old hospitalized in 2005

Interventions—None

Measurements and Main Results—Using ICD-9-CM codes, we identified admissions with neurological diagnoses, analyzed patient and hospitalization characteristics, and generated age- and sex-adjusted national estimates. Of 960,020 admissions in the 11 states, 10.7% (103,140) included a neurological diagnosis, which yields a national estimate of 273,900 admissions of children with neurological diagnoses. The most common were seizures (53.9%) and traumatic brain injury (17.3%). Children with neurological diagnoses had nearly 3 times greater intensive care unit (ICU) use than other hospitalized children (30.6% vs. 10.6%, $p < 0.001$). Neurological diagnoses were associated with nearly half of deaths (46.2%, $n = 1,790$). Among ICU patients,

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children with neurological diagnoses had more than 3 times the mortality of other patients (4.8% vs. 1.5%, $p < .001$). Children with neurological diagnoses had a significantly longer median hospital LOS than other children (3 days [1, 5] vs. 2 days [2, 4], $p < .001$) and greater median hospital costs (\$4,630 [\$2,380, \$9,730] vs. \$2,840 [\$1,520, \$5,550], $p < .001$).

Conclusions—Children with neurological diagnoses account for a disproportionate amount of ICU stays and deaths compared to children hospitalized for other reasons.

Keywords

epidemiology; neurological outcome; pediatric; intensive care; pediatric neurocritical care; hospitalization

INTRODUCTION

Neurological diagnoses are leading causes of morbidity and mortality among children and include both traumatic and non-traumatic injuries and conditions. According to a recent Centers for Disease Control and Prevention report, traumatic brain injury (TBI) is responsible for over 60,000 hospitalizations and 6,000 deaths of US children up to age 19 (1). Schenler et al. found similar figures and specified both a case-fatality of 3.8% and over \$1 billion in total inpatient charges per year for TBI patients (2). Compared to TBI, stroke has a lower incidence but higher mortality, with over 5,000 stroke hospitalizations among children and young adults (3) and a mortality rate of 14.6% for ischemic stroke and 19.5% for intracerebral hemorrhage (4).

Two single-center studies found that a substantial proportion of in-hospital deaths were associated with at least one neurological disorder. In a study of a tertiary children's hospital in the United Kingdom, Ramnarayan, et al. found that the primary diagnosis at death among hospitalized children was neurological in 7.0% of ward patients and 9.3% of intensive care unit (ICU) patients. However, incidence and results by specific diagnosis were not investigated (5). In a US tertiary pediatric ICU (PICU), Au et al. found that, regardless of primary diagnosis, neurological diagnoses were the proximate cause of death in the majority of patients (6).

Given the high morbidity and mortality associated with pediatric neurological diagnoses and recent advances in neurological monitoring and treatment (7, 8), we sought to gain a more comprehensive understanding of the scope and characteristics of children that could benefit from such care. We studied a large sample of hospitalizations in the United States to estimate the incidence, patient characteristics, mortality, and costs of caring for children hospitalized with neurological diagnoses.

MATERIALS AND METHODS

Patients

We constructed a patient database using discharge data for calendar year 2005 from 11 states: Texas (9), Virginia (10), and 9 states from the State Inpatient Databases (SID) of the Healthcare Cost and Utilization Project (HCUP), Agency for Health Care Research and Quality (11) (Arizona, Florida, Iowa, Maryland, Massachusetts, New Jersey, New York, North Carolina, and Washington). The databases include information about all admissions to non-federal hospitals (i.e., excludes military, Indian Health Service, and Veterans Administration hospitals). These 11 states comprised 37.6% of the 2005 US pediatric population (12) and were selected on the basis of their geographic diversity, population sizes, and availability of needed data elements. Data included demographics (age, race, sex,

insurance status); up to 9 discharge diagnoses as classified by the International Classification of Diseases, 9th revision, clinical modification (ICD-9-CM) (13); hospital mortality; hospital and ICU lengths of stay (LOS); and associated charges. Texas provided subject age by age group only; all other states provided age in years. We also obtained US Census population data to determine age- and sex-adjusted incidences and generate weighted national estimates of the number of cases, deaths, and resource use (12).

Case Selection and Definitions

We studied children ages 29 days to 19 years old at hospital admission to take advantage of age groupings used by the US Census and to remove perinatal neurological diagnoses from analysis, because organization of care for neonates differs substantially from that of older children. We use the term “infants” to refer to children between ages 29 and 364 days old. Our goal was to identify patients who were treated for active, as opposed to chronic, neurological disease during hospitalization. We sought to do this by excluding all cases of neurological disease that were considered unlikely to have been a primary reason for hospitalization. Examples include ataxia, dystonia, spinal muscular atrophy, and muscular dystrophy. A full list of selected diagnoses and ICD-9-CM codes is provided in the Appendix. We classified patients as having traumatic and/or non-traumatic neurological diagnosis using ICD-9-CM codes. Non-traumatic diagnoses were categorized as meningitis; encephalitis, myelitis, and encephalomyelitis; brain and spinal cord abscess; CNS encephalopathies; CNS neoplasms; seizures; ischemic and hemorrhagic strokes; hydrocephalus; migraines; syncope; and other non-traumatic neurological diagnoses. Traumatic diagnoses included blunt and penetrating head and spinal cord trauma. We identified severe TBI using the American College of Surgeons Committee on Trauma field triage decision scheme, mapping the anatomic and physiologic indications to ICD-9 Clinical Modification codes (14). Diagnoses included TBI accompanied by diagnoses indicating prolonged loss of consciousness, open fracture of the skull, or traumatic shock. Over half (58.2%) of neurological diagnoses were the primary discharge diagnosis, and 70.5% were the first or second diagnosis. We report the incidence of each diagnosis to account for children admitted with multiple diagnoses, but we include each admission only once when reporting the overall incidence of admissions with neurological disorders.

We identified children with underlying conditions using Pediatric Complex Chronic Conditions definitions developed by Feudtner et al., excluding diagnoses used for acute seizures (15). Neurological disease status and complex chronic conditions status were determined independently. We considered children previously healthy if they lacked a complex chronic condition. We identified children receiving ICU care by the presence of charges for ICU care. We classified hospitals as children’s hospitals or general hospitals based on the National Association of Children’s Hospitals and Related Institutions children’s hospital classification (<http://www.childrenshospitals.net>).

Statistical Analyses

We used data from the US Census to generate age- and sex-adjusted national estimates of hospital and ICU admission by neurological diagnosis. We estimated costs by multiplying charges by hospital-specific cost-to-charge ratios derived from the Centers for Medicare and Medicaid Services Provider Specific File. Because continuous data were not normally distributed, we made comparisons using the Mann-Whitney U test, and we compared categorical data by chi-square or Fisher’s exact tests as appropriate. When values were missing (e.g., race was missing from 7.0% of admissions and payer from 10.6%), percentages were calculated based only on subjects with non-missing values. We conducted analyses in Stata 11.2 (Stata Corp., College Station, TX).

RESULTS

Of 960,020 hospitalizations in the 11 states, 103,140 (10.7%) had neurological diagnoses. This represents an overall age- and sex-adjusted incidence of 3.4/1,000 children per year (Table 1). The highest incidence was among infants (8.6/1,000, $n=13,422$), and the lowest was among 10-14 year olds (2.4/1,000, $n=18,568$). The median age was 5 years older for those with neurological diagnoses than for those without neurological diagnoses (9 [2, 15] vs. 4 [0,14] years, $p<.001$) (Table 1). Children with neurological diagnoses made up a fourth (25.8%, $n=31,530$) of ICU admissions. Children with neurological diagnoses had a longer median hospital LOS than other children (3 [1,5] vs. 2 [2,4] days, $p<.001$) and greater median hospital costs (\$4,360 [\$2,380, \$9,730] vs. \$2,840 [\$1,520, \$5,550], $p<.001$). From these results, we estimate that 273,900 admissions of children with neurological diagnoses occurred in the US in 2005 (Table 2); 83,780 (30.6%) included ICU care, and 4,750 (1.7%) children died. There were 1.5 million hospitalization days and \$3.1 billion of incurred hospital costs.

The most common neurological diagnosis was seizure (53.9% of admissions with a neurological diagnosis), and 2.4% of patients with seizure had status epilepticus (Table 3). TBI was the second most common diagnosis. Collectively, traumatic injuries to the brain and/or spinal cord were present in 17.9% of children with neurological diagnoses. The second most common non-traumatic diagnosis was meningitis (8.6% of admissions with neurological diagnoses). Most cases of meningitis (75.6%) were viral. Stroke was relatively uncommon (1.8% of admissions with neurological diagnoses). Age distribution varied by diagnosis. Nearly half of children with seizures (43.7%) and status epilepticus (49.4%) were under 5 years old. In contrast, nearly half of traumatic injuries (45.3%) were among 15-19 year olds. Infants were much more likely than older children with neurological diagnoses to have had meningitis (23.3% vs. 6.3%, $p<.001$).

Almost a third (30.6%) of admissions with neurological diagnoses included ICU care, which is nearly 3 times greater than the rate of ICU care in hospitalizations for other conditions (10.6%). Rates of ICU care were highest among patients with severe TBI (85.1%), hemorrhagic stroke (76.1%), traumatic spinal cord injury (64.4%), and status epilepticus (63.4%) (Table 3). The most commonly treated neurological diagnosis in the ICU was seizure (12.6% of ICU admissions). ICU patients with neurological diagnoses had greater than twice the rate of mechanical ventilation than ICU patients with other diagnoses (23.8% vs. 9.9%, $p<.001$) (Table 1).

Nearly half (46.2%) of hospital deaths and more than half (53.6%) of deaths among children receiving ICU care were associated with neurological diagnoses. Children with neurological diagnoses had a hospital mortality rate of 1.7%, over 8 times that of children with other conditions (0.2%) (Table 1). Among ICU patients, mortality was also considerably higher among children with neurological diagnoses (4.8% vs. 1.5%, $p<.001$). Mortality was highest among children treated for severe TBI (29.1%), hemorrhagic stroke (14.3%), ischemic stroke (9.9%), and encephalopathy (9.7%) (Table 3). Mortality also varied by presence of an underlying condition. Among all admissions of children with neurological diagnoses, previously healthy children had similar mortality to those with underlying conditions (1.8% vs. 1.6%, $p=.09$). However, among more severely ill patients with neurological diagnoses, those admitted to an ICU, previously healthy children had a higher mortality than those with underlying conditions (5.6% vs. 3.7%, $p<.001$). Among children without neurological diagnoses, previously healthy children had lower mortality than those with underlying conditions (0.1% vs. 0.9%, $p<.001$).

Although the 77 children's hospitals made up only 6.3% of hospitals in the 11 states, they provided care for 54.4% (n=56,123) of admissions with neurological diagnoses. In contrast, children's hospitals provided care for only 40.0% of admissions without neurological diagnoses. Children's hospitals admitted an average of 729 patients per year with neurological diagnoses, whereas general hospitals admitted only 43 per year. Compared to children with neurological diagnoses admitted to general hospitals, those admitted to children's hospitals had higher rates of ICU admission (35.6% vs. 24.5%, $p<.001$), mechanical ventilation (9.6% vs. 7.1%, $p<.001$), underlying conditions (31.7% vs. 18.4%, $p<.001$), and death (2.0% vs. 1.4%, $p<.001$) (Table 4). Children with CNS neoplasms and encephalopathy were almost universally cared for at children's hospitals (90.9% and 87.0% respectively). The majority of children with bacterial or other meningitis, abscess, seizures with or without status epilepticus, stroke, hydrocephalus, and severe TBI were cared for at children's hospitals. Additionally, children with neurological diagnoses admitted to children's hospitals had a longer median hospital LOS (3 [2, 6] vs. 2 [1, 4] days $p<.001$) and median hospital costs (\$5,290 [\$2,790, \$12,090] vs. \$3,570 [\$2,050, \$7,310], $p<.001$).

DISCUSSION

Children hospitalized with neurological diagnoses have a substantially greater use of ICU services, higher risk of death, and higher overall resource use than children hospitalized with other conditions. Even among ICU patients, children with neurological diagnoses account for a disproportionate number of children undergoing mechanical ventilation and deaths. The complexity of care for children neurological diagnoses is also reflected by the higher admission rate to children's hospitals, longer lengths of stay, and higher hospital costs.

No prior studies have investigated the hospital or ICU incidence of neurological diagnoses collectively in a large population of patients. Our findings related to the incidence of pediatric stroke hospitalization are comparable to results of Lo et al., who studied a large, national dataset from 2003. They found that 3.7/100,000 children were hospitalized with ischemic stroke and 2.4/100,000 were hospitalized with hemorrhagic stroke (3, 16). A study of stroke using California state-wide data from 1991-2000 found mortality rates of 14.6% for ischemic stroke, 19.5% for intracerebral hemorrhage, and 16.6% for subarachnoid hemorrhage (4). While these rates are slightly higher than the rates that we found, they are not surprising given the different time period studied, and may also reflect differences between California and the 11 states that we studied. The TBI incidence rate that we found is similar to that published by the Centers for Disease Control (1), and our mortality results are similar to what Schenler et al. found in year 2000 (2).

While the literature lacks studies regarding the ICU admission rate among children with neurological diagnoses, Au et al. recently reported that 28.2% of ICU admissions at their center were for neurological conditions (17), similar to our finding that 26.1% of ICU patients had a neurological diagnosis. While their finding that brain injury was the proximate cause of death in 65.4% of ICU patients was higher than our finding of 53.7%, their facility is a tertiary, level 1 pediatric trauma center with a dedicated neurocritical care service, and they had access to more detailed clinical data than that available in our administrative dataset.

The lower prevalence of underlying conditions, mortality, and resource use suggest that children admitted to general hospitals, on average, are less severely ill or have less complicated hospital courses than those admitted to children's hospitals. This is supported by our findings that the majority of children with less common and/or more severe neurological diagnoses were preferentially admitted to children's hospitals. However, many

children with neurological diagnoses still received ICU care and mechanical ventilation at hospitals caring for few such patients annually, some of whom died.

There are several limitations to this study related to the use of administrative data. First, although these data enable the conduct of broad, population-based analyses, they contain limited clinical information. We chose diagnoses with high likelihood of being active during hospital admission, but it is possible that some may have been chronic, stable conditions. For example, while a large majority (70%) of cases of neurological conditions were coded as the first or second discharge diagnosis, suggesting they were acute and active during the hospitalization, the degree to which that holds for diagnoses in other positions is less certain. As with all studies of discharge data, we also do not know the extent to which coding was influenced by payer reimbursement, leading to documentation bias. In addition, the states that we studied may not be fully representative of the entire US, which would affect our national estimates. In effort to minimize this, we adjusted for sex and age differences between the 11-states and the entire country. We also selected states from geographically diverse locations, with populations that collectively amounted to over a third of the pediatric US population. Our estimates slightly underestimate the national burden of neurological disease because children hospitalized in military and Indian Health Service medical centers were not included in our data set. Data were from 2005, and we do not know if the epidemiology has changed in subsequent years.

Conclusions

This study shows the high prevalence, mortality, and cost of treating neurological diagnoses among children. Our findings will provide a baseline for monitoring the hospitalizations, outcomes, and care patterns for children with neurological diagnoses as new therapies and health policies evolve.

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APPENDIX

Diagnosis Category	Specific Diagnosis	ICD-9-CM Code
Non-Traumatic	Bacterial	036.0, 098.82, 320.0/320.9
	Viral	047.0/047.9, 49.0, 049.1, 053.0, 054.72, 072.1
	Other	013.00/013.26, 091.81, 094.2, 112.83, 114.20, 115.01, 115.11, 115.91, 321.0/322.9
Encephalitis, myelitis or encephalomyelitis	Bacterial encephalitis or encephalomyelitis	036.1
	Viral encephalitis or encephalomyelitis	046.2, 046.3, 052.0, 054.3, 055.0, 056.01, 058.21, 058.29, 062.0/064 066.41, 072.2, 323.01, 323.02
	Other encephalitis or encephalomyelitis	013.60/013.66, 323.2, 323.41, 323.51, 323.61, 323.61, 323.62, 323.71, 323.81, 323.9
	Myelitis	341.20/341.22, 323.42, 323.52, 323.63, 323.72, 323.82
Abscess	Brain	013.30/013.36, 324.0, 324.9

Diagnosis Category Non-Traumatic	Specific Diagnosis	ICD-9-CM Code
Encephalopathy	Spinal cord	013.50/013.56, 324.1
	Transmissible Spongiform	046.11, 046.19, 046.71/046.79
	Hypoxic ischemic	348.1
	Metabolic & toxic	333.72, 348.31, 349.82
	NOS	348.30 348.39
CNS Neoplasm	Hypertensive	437.2
	Benign	191.0/191.9, 192.1/192.9, 194.3, 198.3, 198.4
	Malignant	225.0, 225.2/225.8
	Unspecified	237.0/237.2, 237.5, 237.6
Stroke	Hemorrhagic	433.01/434.91, 436
	Ischemic	430, 431
Seizure	CNS venous thrombosis	437.6, 325
	Seizure	345.00, 345.10, 345.40, 345.50, 345.60, 345.61, 345.80, 345.90, 780.39
	Intractable seizure	345.01, 345.11, 345.41, 345.51, 345.81, 345.91
	Status epilepticus	345.2, 345.3
	Partial status epilepticus	345.70, 345.71
Hydrocephalus	Febrile convulsions	780.31, 780.32
	Hydrocephalus	331.3, 331.4, 331.5
Migraine	Migraine	346.00/346.93
Syncope	Syncope	780.2
Other	Spinal cord TB	013.40/013.46
	Other CNS TB	013.80/013.96
	Other CNS viral	046.8, 046.9, 048, 049.8, 049.9, 056.00, 056.09, 066.42
	Other CNS bacterial	090.40, 094.89, 094.9
	Congenital syphilitic encephalitis	090.41
	Congenital syphilitic meningitis	090.42
	Hypoglycemic coma	251.0
	Type 1 Diabetic coma	250.31, 250.33, 249.30, 249.31
	Type 2 diabetic coma	250.30, 250.32
	Reyes Syndrome	331.81
	Myoclonus	333.2
	Other choreas	333.5
	Genetic torsion dystonia	333.6
	Other cerebellar ataxia	334.3
	Other spinal cord	335.8/336.9
	Demyelinating disorders	340, 341.1, 341.8, 341.9
	Pseudotumor cerebri	348.2
	Compression of brain	348.4

Diagnosis Category	Specific Diagnosis	ICD-9-CM Code
Non-Traumatic	Cerebral edema	348.5
	Nervous system complications from surgically implanted device	349.1
	Disorders of meninges, not elsewhere classified	349.2
	Unspecified disorders of nervous system	349.90/349.93
	Hemorrhage	432.0/432.9
	Ischemia	435.0/435.9, 437.1
	Cerebral aneurysm	437.3
	Cerebral arteritis	437.4
	Moyamoya disorder	437.5
	Coma NOS	780.01
	Aphasia	784.3
Traumatic Brain		
Injury		
Anatomically severe head injury	Open fracture of the vault of the skull with cerebral laceration/contusion	800.60/800.69
	Open fracture of the vault of the skull with subarachnoid subdural and extradural hemorrhage	800.70/800.79
	Open fracture of the vault of the skull with subarachnoid subdural and extradural hemorrhage	800.80/800.99
	Open fracture of base of the skull with other/unspecified intracranial hemorrhage	801.60/801.99
	Other open skull fracture	803.60/803.99
	Open fractures involving skull or face with other bones	804.60/804.99
	Cortex (cerebral) contusion with open intracranial wound	851.10/851.19
	Cortex (cerebral) laceration with open intracranial wound	851.30/851.39
	Cerebellar or brain stem contusion with open intracranial wound	851.50/851.59
	Cerebellar or brain stem laceration with open intracranial wound	851.70/851.79
	Other and unspecified cerebral laceration and contusion with open intracranial wound	851.90/851.99
	Subarachnoid hemorrhage following injury with open intracranial wound	852.10/852.19
	Subdural hemorrhage	852.30/852.39

Diagnosis Category Non-Traumatic	Specific Diagnosis	ICD-9-CM Code
	following injury with open intracranial wound	
	Extradural hemorrhage following injury with open intracranial wound	852.50/852.59
	Other and unspecified intracranial hemorrhage following injury with open intracranial wound	853.10/853.19
	Intracranial injury of other and unspecified nature with open intracranial wound	854.10/854.19
Physiologically severe head injury	Concussion with prolonged loss of consciousness	850.3 850.4
Traumatic Spinal Cord Injury	Fracture of vertebral column with spinal cord injury	806.00/806.9
	Spinal cord injury without evidence of spinal bone injury	952.00/952.9

Abbreviations used

ICD-9	International Classification of Diseases, Ninth Revision, Clinical Modification
ICU	intensive care unit
PICU	pediatric intensive care unit
TBI	traumatic brain injury
LOS	length of stay
NCHS	National Center for Health Statistics

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Table 1

Patient characteristics by presence of a neurological diagnosis and ICU status

	All Admissions		p	ICU Admissions		p
	With Neurological Diagnosis N=103,140	Without Neurological Diagnosis N=856,880		With Neurological Diagnosis N=31,530	Without Neurological Diagnosis N=90,560	
Percent of admissions	10.7	89.3		25.8	74.2	
Annual incidence (per 1,000 children)	3.4	27.9		1.0	3.0	
Male, %	55.7	53.3	<.001	58.6	55.5	<.001
Age, y			<.001			<.001
Mean $\pm$ SD	8.9 $\pm$ 6.6	6.9 $\pm$ 7.0		9.2 $\pm$ 6.7	7.1 $\pm$ 7.1	
Median (IQR)	9 (2, 15)	4 (0, 14)		9 (2, 16)	4 (0, 15)	
Age group, % by diagnosis status			<.001			<.001
29-364 d	13.0	29.3		12.9	29.2	
1-4 y	23.7	21.9		22.8	21.1	
5-9 y	17.6	12.6		16.8	11.7	
10-14 y	18.0	13.8		17.8	13.7	
15-19 y	27.7	22.4		29.8	24.3	
Race/ethnicity (%)			<.001			<.001
White	49.4	47.9		49.4	46.8	
Black	18.4	19.7		18.1	21.3	
Hispanic	22.0	23.0		21.9	21.7	
Other	10.2	9.4		10.6	10.3	
Insurance coverage (%)			<.001			<.001
Medicare	0.2	0.3		0.4	0.4	
Medicaid	42.9	42.7		41.8	42.1	
Private insurance	48.7	49.0		49.1	48.9	
Self-Pay/Uninsured	8.1	8.1		8.8	8.6	
Underlying condition (%)			<.001			<.001
Neuromuscular	19.7	1.7		23.1	4.0	
Cardiovascular	3.9	3.7		6.1	14.7	
Respiratory	1.3	1.1		1.9	3.3	
Renal	0.5	0.8		0.6	1.2	
Gastrointestinal	0.4	1.1		0.3	1.5	
Hematologic/Immunologic	0.7	0.9		0.7	1.2	
Metabolic	1.2	0.8		1.3	1.7	
Other congenital or genetic	2.7	1.7		3.0	5.2	
Malignancy	7.2	4.2		8.4	5.7	

	All Admissions			ICU Admissions		
Any underlying condition	25.6	12.2		29.9	25.9	
Hospital mortality, %	1.7	0.2	<.001	4.8	1.5	<.001
Mechanical ventilation, %	8.4	1.8	<.001	23.9	9.9	<.001
Hospital length of stay (d)			<.001			<.001
Mean $\pm$ SD	5.5 $\pm$ 11.9	4.3 $\pm$ 9.9		8.4 $\pm$ 14.3	7.9 $\pm$ 14.6	
Median (IQR)	3 (1, 5)	2 (2, 4)		4 (2, 9)	4 (2, 8)	
Hospital Cost, US dollars			<.001			<.001
Mean $\pm$ SD	\$11,360 $\pm$ \$26,780	\$6,530 $\pm$ \$18,680		22,050 $\pm$ 38,650	\$18,540 $\pm$ \$37,820	
Median (IQR)	\$4,360 (\$2,380, \$9,730)	\$2,840 (\$1,520, \$5,550)		\$10,140 (\$4,780, \$23,440)	\$7,560 (\$3,740, \$18,140)	

y = year; SD = standard deviation; IQR = interquartile range; d = day

Table 2

US incidence, number of cases, and deaths associated with neurological diagnoses by age

	Annual incidence (per 1,000 population)	Number of US cases	Number of US deaths
Total hospitalized	3.4	273,940	4,750
Age group n (%)			
29-364 d	8.6	35,260	750
1-4 y	4.0	64,030	870
5-9 y	2.5	48,110	590
10-14 y	2.4	49,710	710
15-19 y	3.7	76,830	1,830
ICU hospitalizations	1.0	83,780	4,030
Age group			
29-364 d	2.6	10,650	590
1-4 y	1.2	18,790	760
5-9 y	0.7	14,050	510
10-14 y	0.7	15,020	590
15-19 y	1.2	25,280	1,580

ICU = intensive care unit; d = day; y = year

Table 3

Diagnoses, ICU care, and mortality among children with neurological diagnoses (n=103,140)

	Patients with diagnosis (%)	ICU care (%)	Children's hospital care (%)	Hospital mortality (%)
Meningitis	8.6%	14.4%	44.6	0.8%
Bacterial	1.3%	45.9%	60.5	3.7%
Viral	6.5%	6.6%	41.7	0.0%
Other	0.9%	25.2%	62.5	2.2%
Encephalitis, myelitis, or encephalomyelitis	0.5%	41.2%	33.3	1.9%
Abscess	0.3%	59.6%	72.5	0.6%
Encephalopathy	5.1%	48.9%	87.0	9.7%
CNS neoplasm	5.4%	35.8%	90.9	2.2%
Seizures without status epilepticus	51.6%	25.7%	55.0	0.9%
Status epilepticus	2.4%	63.4%	61.2	1.8%
Stroke	1.8%	64.1%	69.3	10.6%
Ischemic stroke	0.9%	59.4%	70.5	9.9%
Hemorrhagic stroke	0.7%	76.1%	68.8	14.3%
Venous thrombosis	0.2%	48.1%	73.8	2.2%
Hydrocephalus	6.5%	43.3%	74.9	2.2%
Migraine	4.7%	9.9%	43.9	0.1%
Syncope	3.7%	19.7%	42.0	0.1%
Traumatic injury	17.9%	51.5%	48.5	3.5%
TBI	17.3%	51.2%	49.4	3.9%
Severe TBI	0.7%	85.1%	54.5	29.1%
Spinal cord injury	0.8%	64.4%	47.1	4.1%
Other neurological diagnosis	6.6%	44.4%	65.1	5.9%

* Percentages do not add up to 100% because some children had more than one neurological diagnosis

ICU = intensive care unit; CNS = central nervous system; TBI = traumatic brain injury

Table 4

Characteristics, outcomes, and resource use among children with neurological diagnoses admitted to children's vs. general hospitals

	Children's Hospitals 77 hospitals, 56,123 admissions	General Hospitals 1096 hospitals, 47,020 admissions
Admissions per hospital, mean	729	43
Patient age, y		
Mean $\pm$ SD	8.1 $\pm$ 6.3	9.7 $\pm$ 6.9
Median (IQR)	7 (2,14)	10 (2,17)
Underlying conditions (%)	31.7	18.4
Mechanical ventilation (%)	9.6	7.1
ICU Stay (%)	35.6	24.5
Hospital mortality (%)	2.0	1.4
LOS, days		
Mean $\pm$ SD	5.9 $\pm$ 11.9	5.0 $\pm$ 12.0
Median (IQR)	3 (2,6)	2 (1,4)
Hospital cost, US dollars		
Mean $\pm$ SD	\$13,470 $\pm$ \$30,770	\$8,960 $\pm$ \$21,070
Median (IQR)	\$5,290 (\$2,790, \$12,090)	\$3,570 (\$2,050, \$7,310)

All differences between children's and general hospitals were statistically significant ($p < .001$)

y = years; LOS = length of stay; SD = standard deviation; IQR = interquartile range