

More Hemorrhagic and Severe Events Cause Higher Hospitalization Care Cost for Childhood Stroke in Taiwan

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Objective Rarely has childhood stroke been compared with adult stroke for incidence or cost. This population study compared the stroke incidence and the associated hospitalization care costs between children and adults in Taiwan.

Study design We used reimbursement claims data from the National Health Insurance program to identify stroke diagnoses in 1997 to 2003. The inpatient costs of both the first admission and recurrent stroke from 1979 childhood cases and 365,169 adult cases were compared by age and stroke subtype, excluding those less than 1 month of age.

Results The mean inpatient costs were higher for patients <10 and 10 to 19 years of age (\$3565 per case) compared with adult cases (\$1933), including both first and recurrent hospitalizations, and they were higher for the recurrent cases. Patients <10 years old had the highest proportional incidence of hemorrhage events (71.4%), followed by patients in the 10- to 19-year-old group (61.4%), and the lowest for adults (21.3%). Hemorrhagic events incurred 2 to 12 times higher cost than other types of stroke.

Conclusions The hospitalization care costs for stroke are higher for children than for adults because of a greater proportion of hemorrhagic cases among children. (*J Pediatr* 2008;152:388-93)

Stroke is a costly disease. The techniques used for diagnosis, medication used for lifelong care, and the long-term rehabilitation required for survivors are an enormous burden on healthcare expenditure.¹⁻³ Although the mortality rate⁴ and case fatalities^{5,6} from stroke have declined over recent decades, it is still among the top 3 causes of death in most developing countries.^{4,7} There is uncertainty whether the mortality rate reduction is due to a decrease in incidence, improvement in survival, or both. Several studies have suggested that the incidence of stroke may have reached a plateau or even increased in some areas^{8,9} and that the hospitalization rate is increasing as well.¹⁰ This indicates that the burden on healthcare for stroke remains high.

Many studies estimated hospital care¹¹⁻¹⁴ and lifetime¹⁵ costs for stroke. The cost varies with the stroke subtype.^{11,12,15} The severity of the disease, length of stay (LOS) at hospital, and sequelae after discharge are important factors for the variation in cost.^{3,11,13} Reed et al¹² reported that patients with subarachnoid hemorrhage (SAH) incurred the highest costs, followed by intracerebral hemorrhage (ICH), ischemic cerebral infarction, and transient cerebral ischemia (TIA). However, this study focused on adults rather than the young.

Estimates of the incidence rates for childhood stroke ranged from 2.1 to 13 per 100,000 children-years in Hong-Kong,¹⁶ the United States,¹⁷ and France.¹⁸ Although they are uncommon, children who have strokes may have long-term morbidity and economically adverse neurologic consequences.¹⁹

In Taiwan, the mortality rate from stroke is high, ranking the second-most common cause of death.²⁰ There are limited studies on the occurrence of childhood stroke in Taiwan and no studies on the medical costs of stroke in children. The goals of this study were to compare the occurrence of stroke by subtype and the associated cost of hospitalization between children and adults.

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HS	Hemorrhage stroke	LOS	Length of stay
ICD-9-CM	International classification of disease-9-clinical modification	NHI	National health insurance
ICH	Intracerebral hemorrhage	OIH	Other intracranial hemorrhage
IS	Ischemic stroke	SAH	Subarachnoid hemorrhage
		TIA	Transient cerebral ischemia

METHODS

Database and Study Population

The National Health Insurance (NHI), a universal health program, was established in Taiwan in 1995. The NHI covers more than 96% of the population and has contracted with 97% of the hospitals in Taiwan.^{21,22} Its medical claims data for reimbursement have been computerized since 1996. Hospitalization data were obtained for this study from the National Health Research Institute, which maintains the NHI database. The data contained information on sex, birthday, and patient encrypted identification numbers, dates of admission and discharge, function types, LOS as inpatients, discharge diagnoses (up to 5), operation procedures (up to 5), discharge disposition and costs (i.e. expenditures) by admission. The cost components include fees for diagnosis, room and meals, laboratory tests, radiography services, therapeutic treatment, operation, rehabilitation, blood products, hemodialysis, anesthetic, special medical supply, medication, and other services. All first admissions for stroke from 1997 to 2003, excluding neonates (age less than 1 month), formed the study population. Their succeeding admissions were also identified for the cost analysis. Inpatients with stroke were identified using primary discharge diagnosis for ICD-9-CM code 430 to 437. Three inpatients with a total cost 100 times greater than the average cost were excluded from the cost analyses.

Definitions of Stroke Subtypes, Costs and Length of Stay at Hospital

The stroke types were classified according to the following ICD-9-CM codes: 430, subarachnoid hemorrhage (SAH); 431, intracerebral hemorrhage (ICH); 432, other intracranial hemorrhage (OIH); ischemic stroke (IS), including 433 (occlusion and stenosis of precerebral arteries), 434 (occlusion of cerebral arteries); 435, transient cerebral ischemia (TIA); and other cerebrovascular disease (others), including 436 (acute, but ill-defined cerebrovascular disease) and 437 (other and ill-defined cerebrovascular disease). For each admission and discharge, the total medical costs were estimated by use of the sum of all cost components. The duration between admission and discharge dates were calculated as LOS. Costs expressed in this study were in US dollars (\$1 U.S. is approximately \$33 in Taiwanese currency).

Statistical Analysis

We plotted mean costs and LOS of the first admission and succeeding hospitalizations of recurrent stroke to compare the trends by age. We also estimated age-, sex-, and subtype-specific stroke incidence rates with the first stroke admissions divided by the population person-years for the study in the age bands <10, 10 to 19, and ≥20 years.²³ Further analysis compared average and median costs between young children, adolescents, and adults by stroke subtype for the first and succeeding admissions. One-way analysis of

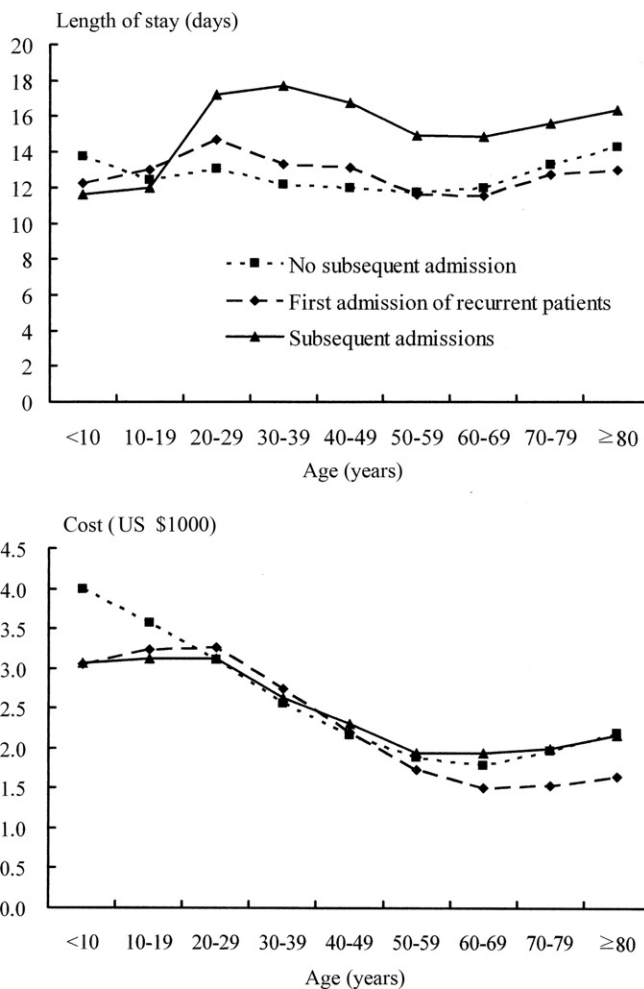


Figure. Length of stay and average cost during hospitalization care for stroke by patient's age for first and recurrent admissions in Taiwan, 1997-2003.

variance was used to examine the differences in mean costs among these 3 age groups. We tested for the mean cost trends across age groups with the linear trend test (GLM procedure). Two multiple linear regression models were used to assess the excess cost associated with age controlling for sex, stroke subtypes, LOS, type of hospital services, outcome at discharge (dead or not), and seasonal and secular factors. In the second model, we compared costs between the first hospitalizations and subsequent hospitalizations for patients with recurrent events. Further regression analysis was also performed with natural-log transformation for costs and LOS in the regression equation. The linear regression assumptions, potential outliers and influential points in the model were also examined. The statistical significance level was set at $P < .05$. All analyses were performed with SAS 9.1 (SAS Institute Inc., Cary, NC).

RESULTS

For the period 1997 to 2003, we identified 209,904 (57.2%) men (and boys) and 157,244 (42.8%) women (and girls) as stroke incidence cases from the initial hospitalization

Table I. Annual average stroke incidence rate for each subtype by age and sex, Taiwan, 1997-2003

Sex/Age, years	No. of first admission	Person-years	Rate, per 100,000 person-years*						
			SAH	ICH	OIH	IS	TIA	Others	Total
Men (or boys)									
<10	549	11,299,614	0.5	0.9	2.2	0.5	0.1	0.6	4.9
10-19	642	12,695,542	0.9	1.6	0.6	0.8	0.3	0.8	5.1
≥20	208,713	55,334,282	8	66.7	11.4	189.6	41.7	59.7	377.2
Total	209,904	79,329,438	5.8	46.9	8.4	132.5	29.1	41.9	264.6
Women (or girls)									
>10	358	10,379,554	0.4	0.7	1.2	0.5	0.1	0.5	3.4
10-19	430	11,874,974	0.6	1.2	0.3	0.6	0.3	0.6	3.6
≥20	156,456	53,447,832	10.5	41.6	4.5	145.3	38.1	52.7	292.7
Total	157,244	75,702,360	7.6	29.7	3.4	102.7	27	37.4	207.7
All									
<10	907	21,679,166	0.5	0.8	1.7	0.5	0.1	0.6	4.2
10-19	1072	24,570,516	0.8	1.4	0.5	0.7	0.3	0.7	4.4
≥20	365,169	108,782,115	9.2	54.4	8	167.8	39.9	56.3	335.7
Total	367,148	155,031,797	6.7	38.5	6	118	28.1	39.7	236.8

*Numbers of first admission for stroke per 100,000 person-years in each subgroup during the study period.

records. Among children (1 month to 19 years of age), the average stroke incidence rate was highest in those <5 years old (6.1 per 100,000), followed by 15- to 19-, 10- to 14-, and 5- to 9-year-old children, and was higher in boys than in girls (data not shown). The average cost of care during the first hospitalization declined with increasing age to the lowest for 60- to 69-year-old patients (Figure). The average LOS ranged approximately 11 to 13 days among age groups with no recurrent admission, except for the youngest and the oldest who exhibited an upward trend. The average LOS for subsequent admissions was 2.3 to 4.5 days greater in adults. For patients with no subsequent admissions, the highest mean cost was \$3991 for <10-year-old children, and the lowest mean cost was \$1780 for 60- to 69-year-old patients. The average costs and LOS of succeeding hospitalizations for recurrent cases were higher than those for the initial hospitalization among adults but not children. The overall average daily cost decreased from approximately US \$279 for children <10 years old to \$129 for patients 70 to 79 years old (data not shown).

Table I shows that about half (49.8%) of patients were hospitalized for ischemic events (118 per 100,000 person-years), and 21.6% of patients had hemorrhage-related strokes (SAH, ICH, and OIH) (51.2 per 100,000 person-years). Approximately 60% to 70% of strokes among children were due to hemorrhage, and IS was the major type among adult patients (50%). The relative incidence rates of hemorrhage events were higher in patients <10 years old (71.4%) and 10 to 19 years old (61.4%) than in adults (21.3%). The stroke distributions by subtype among these age groups were approximately similar for both sexes.

Table II (available at www.jpeds.com) shows the average and median costs for patients with stroke by stroke subtype and age. Overall, the average costs were higher for recurrent events than for the initial events. Inpatients with hemorrhagic events had higher average costs than those with

ischemic and other events. Among the initial hospitalization, SAH was the most costly stroke subtype on average (\$6098), followed by ICH, OIH, IS and other type, with TIA the least expensive (\$501). The mean costs were higher in children than in adults among inpatients with ICH, IS, and other types of stroke ($P < .001$). The mean costs had significant inverse linear relationships with age except for inpatients with SAH and TIA. These patterns remained when the cost associations with age and stroke subtype were evaluated with median costs. For patients with SAH, the mean cost was higher in adults than in other age groups ($P = .001$).

In the multiple regression analysis, type of hospital, sex, age, stroke subtype, LOS, outcome at discharge, and seasonal/secular factors were significant predictors of the hospital care cost for stroke and explained 60.1% of the variation for patients with no subsequent admission (Model 1 in Table III). Compared with adults, excess costs for inpatient care were \$765.4 for <10-year-old children and \$236.9 for 10- to 19 year-old adolescents ($P < .001$ for both). Overall, the cost for SAH was notably higher than the cost for other types of stroke, and the difference between ICH and OIH was negligible. A similar pattern was found when the regression analysis included only recurrent cases (Model 2).

DISCUSSION

This study revealed an important pattern by highlighting the relationship between childhood stroke subtype and cost, which has not been reported in previous studies. Taiwan's NHI is a single-payer, government-run, mandatory-enrollment health insurance program, which aims to ensure equitable access to health care for all ages and to provide a wide scope of health care services.²⁴ This insurance scheme enabled us to obtain the representative cost estimations by stroke subtype for all ages from the nationwide hospitalization database.

Table III. Multiple linear regression analysis for cost (US \$) of hospital care for stroke

	Model 1*		Model 2*	
	Coefficient (SE)	P	Coefficient (SE)	P
Intercept	-608.4 (19)	<.001	-663.3 (22.7)	<.001
Hospital level (vs. Community Hospital or others)				
Medical center	424.8 (12.8)	<.001	813 (13.3)	<.001
Regional hospital	262 (11.7)	<.001	359.8 (11.9)	<.001
Sex, men or boys (vs women or girls)	-54.9 (9.5)	.005	-57.1 (10.2)	<.001
Age, years (vs ≥20)				
<10	765.4 (92.3)	<.001	562.6 (125.2)	<.001
10-19	236.9 (83.7)	<.001	314.2 (125.4)	.012
Stroke subtype (vs TIA)				
SAH	3693 (31.5)	<.001	3430.4 (39.3)	<.001
ICH	1166.1 (18.3)	<.001	1238.9 (21.4)	<.001
OIH	1060.2 (31.9)	<.001	1061.2 (40.4)	<.001
IS	-34.3 (14.9)	.022	110.8 (17.7)	<.001
Others	70.2 (17.6)	<.001	110 (19.9)	<.001
Length of stay, days	136 (0.2)	<.001	101.1 (0.2)	<.001
Deceased at discharge (vs alive)	1790.9 (26.6)	<.001	2161.4 (47.3)	<.001
Year of admission (vs 1997-1998)				
1999-2000	177.7 (12.8)	<.001	193.8 (13.5)	<.001
2001-2003	296.8 (11.6)	<.0001	364.5 (12.7)	<.001
Season of admission (vs spring)				
Summer	10.3 (13.4)	.442	15.8 (14)	.261
Fall	43.2 (13.3)	.001	31.8 (14.1)	.024
Winter	42.6 (13.2)	.001	31.4 (14)	.026
First-hospitalized (vs recurrent)	—	—	-130.5 (10.6)	<.001

Model 1 includes inpatients with no succeeding admission; Model 2 includes inpatients with subsequent admissions during study periods. Two first- and 2 recurrent-admissions were excluded because of extremely high cost.

*Adjusted R²: 0.601 for model 1; 0.54 for model 2.

The principal determinants in stroke hospitalization care cost are LOS, stroke subtype, and the severity of the disease.³ Our analysis indicated a downward trend in average hospitalization costs as patient's age increased, even though the LOS of the initial admission were similar among most age groups except for the elderly and the 20- to 29-year-old patients. The association between age and inpatient cost was controversial in previous studies, which focused on adulthood stroke. In the United States, after adjusting for covariates, inpatients aged 80 to 89 and ≥90 years old are 30% and 53% less costly, respectively, compared with those 19 to 49 years of age,¹² a trend somewhat similar to our study.

In Japan, the cost of inpatient care for IS and ICH in those less than 70 years of age is similar to that of older patients.¹⁴ Another earlier study in the U.S. suggested that demographic factors such as age and sex accounted for less than 10% of the variation in hospitalization cost, whereas LOS explained more than 72% of the variation.¹¹ Our analysis suggests that the age of patients and stroke types have a greater implication for cost than LOS has, especially when considering childhood stroke. The highest average cost occurs on those <10 years of age for the initial hospitalization, followed by 10- to 19-year-old patients, and independent of the stroke subtype, LOS, sex, and survival status at discharge. However, the cost was the highest for 20- to 29-year-old patients in the recurrent cases. Further analysis showed that

hemorrhagic stroke also had greater cost in these recurrent cases.

We confirmed the observation of previous studies that IS (or cerebral infarction) is much more common than hemorrhagic events in adulthood stroke.²⁵⁻²⁷ For childhood stroke, several population studies have shown variation among geographic areas.^{16-18,28-31} The first study conducted in the United States reviewed medical records from a Rochester, Minnesota, records-linkage system from 1965 to 1974 for 15,834 children <15 years old of age.²⁸ The incidence rate of HS was higher than that of IS (1.89 vs 0.63 per 100,000). Two other studies with short observation period, also for children of <15 years in Cincinnati (n = 295,577) and Washington, DC (n = 773,016), revealed less remarkable incidence differences between IS and HS.^{29,30} A study in California (n = 9,907,432) reported incidence rates of 2.4/100,000 for all strokes, and 1.2/100,000 for both IS and HS.¹⁷ A recent study in Texas (n = 92,418) yields much greater incidence for HS than for IS (3.2 vs 1.1 per 100,000).³¹ However, the U.S. National Hospital Discharge Survey from 1980 to 1998 showed that, among all stroke events, the rate of hospitalization for IS was higher than that for SAH and ICH together among children aged 0 to 18 years old (7.8 vs 2.9 per 100,000 children per year).³² Higher incidence rates for IS than for HS have also been reported in the Hong-Kong childhood stroke registry¹⁶ and in Dijon,

France.¹⁸ No cost analysis for the care of childhood stroke is available in the above studies.

Children in Taiwan are more likely than children in other areas to have HS, a notable difference from adults. Although Asians are at higher risk than Caucasians for ICH and SAH,³³ the different pattern we found is not explained well by genetic variation because children in both Hong-Kong¹⁶ and Taiwan are predominantly Chinese. A previous study demonstrated a striking variance in stroke subtypes among adult populations in different provinces of China.²⁶ Although all the populations are from the same race, the percentages of HS varied from 19% to 42% of strokes. Furthermore, compared with non-Hispanic white, Asians/Pacific Islanders in the United States have a greater geographic variation of stroke incidence, indicating a significant interaction between race and regional variation.³³

This study confirmed that it costs more to care for hemorrhagic events than for ischemic events, consistent with earlier studies.^{11,12,14} SAH, ICH, and OIH cost the most among all stroke events, and these types of stroke are at higher proportional incidence in children in Taiwan. The high cost among children, found in this study, is well explained by the high HS incidence. The disease may be more severe and complicated in children than in adults, requiring more intensive care and complex treatments or procedures, resulting in high cost.

The increased cost for the children may be related to physiological and psychological elements. The frequently encountered causes of pediatric stroke, different from that for adults, may include heart disease, moyamoya disease, hereditary diseases, and vascular anomalies.^{16,32} These diseases require more investigation such as angiography, echocardiography, coagulation, and hematologic studies. More specific therapies such as endovascular therapy may be performed for stroke in children. Also, parents' expectation for stroke care in children may be higher. Further analysis of our data showed that childhood stroke cases did undergo more radioactive scans and therapeutic treatment than adults. They also undergo more surgeries, particularly for ICH (46.6% for patients <10 years old, 44.1% for patients 10 to 19 years old, and 28.9% for all adults in average). The average fees of surgery, laboratory, and medicine were notably higher for children with this type of stroke (data not shown).

There are limitations in this study. First, our study excluded uninsured patients with stroke. However, with an insurance coverage rate of 96%, our estimation is believed to be representative for the population of Taiwan. Second, this study did not include outpatient care and non-hospital costs. It is important to include these costs for evaluating the overall economic impact of stroke, although our study aimed to observe the pattern of stroke admission. Third, the diagnostic practice by ICD code may not be totally the same in different areas. But it is unlikely to alter the pattern of stroke subtype among age groups we observed because the use of neurologic imaging techniques is now widespread. Finally, the multiple regression analysis might be affected by the skewed distribu-

tions in cost and LOS, and the skewed LOS distribution among patients with different stroke subtypes might affect the cost estimation. However, our focus was the comparison of hospital care cost among children, adolescents, and adults, and the inverse association between these age groups and cost was robust after controlling for these covariates. The cost associated with age and the subtype of stroke was similar in pattern whether the cost is estimated for whole hospital care or cost per day.

Findings from this study suggest a higher inpatient cost for childhood stroke in Taiwan than adulthood stroke. The disparity in cost is associated with the pattern of stroke-subtype and the complexity of the disease.

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Table II. Average hospital care cost (US\$) for first-hospitalized and recurrent strokes* by subtype and age, Taiwan, 1997-2003

Stroke subtype	Age, years									No.	Total		P value†	P value‡	
	<10			10-19			≥20				No.	Mean			Median
	No.	Mean	Median	No.	Mean	Median	No.	Mean	Median						
SAH															
First-hospitalized	98	5531	3090	196	4120	1860	10,036	6142	3201	10,330	6098	3169	.001	.007	
Recurrent	9	2550	1715	32	6937	3064	2624	6335	3900	2665	6330	3863	.297	.435	
ICH															
First-hospitalized	184	5255	3284	345	5125	2570	59,157	3912	1788	59,686	3923	1795	<.001	<.001	
Recurrent	34	4441	2830	58	2956	1841	19,401	3894	1830	19,493	3892	1833	.460	.846	
OIH															
First-hospitalized	374	3658	2167	116	3727	1579	8743	3104	1603	9233	3134	1621	.108	.044	
Recurrent	75	3157	1832	13	1875	1492	2624	3392	1683	2712	3378	1685	.656	.631	
IS															
First-hospitalized	115	2442	1074	178	2478	1136	182,580	1554	704	182,873	1555	704	<.001	<.001	
Recurrent	11	1176	745	36	1466	1033	73,577	1845	812	73,624	1844	812	.717	.416	
TIA															
First-hospitalized	13	764	323	68	485	349	43,442	501	370	43,523	501	369	.549	.547	
Recurrent	2	672	672	6	624	371	12,757	551	377	12,765	551	377	.963	.784	
Others															
First-hospitalized	123	2540	1039	169	1731	758	61,209	1094	462	61,501	1099	463	<.001	<.001	
Recurrent	86	2805	1846	60	2744	1771	26,492	1323	552	26,638	1331	555	<.001	<.001	
Total															
First-hospitalized	907	3837	1921	1072	3521	1341	365,167	1897	676	367,146	1906	678	<.001	<.001	
Recurrent	217	3070	1826	205	3117	1671	137,475	2029	768	137,897	2032	770	<.001	<.001	

*Two first- and 2 recurrent-admissions were excluded because of extremely high cost.

†P values for differences among means were estimated with 1-way analysis of variance.

‡The trend of mean cost across ages was examined with linear trend testing.