Cost of Acute and Sub-Acute Care for Stroke Patients

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Background: *Stroke is an important health problem that imposes socioeconomic burdens.*
Objective: *To explore provider costs and to examine predictive factors for cost of acute and sub-acute inpatient services for stroke patients.*
Material and Method: *The present study design was prevalence-based cost-of-illness with micro-costing approach. Subjects were 407 first episode stroke patients. Patient costs were prospectively recorded from July 2008 to March 2009.*
Results: *The average cost per admission was 32,372 Baht. The cost of acute phase was higher than that of sub-acute phase. Moreover, costs were significantly different among disability levels. Predictors of cost in acute phase included surgery, hemorrhagic pathology, and length of stay (adjusted $R^2 = 0.755$; $p < 0.001$). Additional predictors of costs in sub-acute phase included initial Barthel index, gender, rehabilitation treatment, and the hospital (adjusted $R^2 = 0.748$; $p < 0.001$).*
Conclusion: *Cost of stroke was influenced by patient characteristics, pathology, treatments, and phases of care that should be considered in reimbursement system policy.*

Keywords: *Cost of stroke, Acute, Sub-acute care, Micro-costing approach*

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Stroke is an important health problem that imposes socioeconomic burdens on both patients and care givers[1]. Most stroke cases (75 to 80% of the total) are caused by local ischaemic necrosis of brain tissue, and the rest are hemorrhagic, either primary intracerebral (15%) or subarachniod (10%)[2]. Worldwide, stroke is the third leading cause of death, following heart disease and cancer[3,4].

In 2005, the World Health Organization (WHO) reported that six million people die from stroke each year or 11 persons every minute. Ten percent of all causes of deaths were from strokes. It was estimated that 20 million people would die from heart disease and stroke in 2015[5]. In addition, the rate of stroke is expected to continue to increase given that the population at risk for stroke is rapidly increasing. Survival rate also increases due to advances in technology. The integrity of motor, sensory and cognitive functions often affect individuals with stroke[6,7]. WHO in 2002 found that stroke was the second leading cause of long-term burden of impairment and disability[8]. Furthermore, stroke is the primary cause of physical disability in people over 60 years of age[2]. In America, Europe and Australia, new cases of stroke occur approximately 400 per 100,000 in people older than 45 and 40% of 4.4 million survivors faced with moderate functional impairments and 15 to 30% severely disabled[9]. In Australia, the cost of stroke was estimated to be US$ 985 million in 2001, the largest cost components were acute hospitalization (28%), inpatient rehabilitation (27%), and nursing home care (11%)[10]. Acute care cost was US$ 3,251 per person in Canada[11], US$ 6,887 per person or US$ 209 per day in Japan[12], 16,000 Euro per patient in the Netherlands, and US$ 103,576 per lifetime in the US[13].

In Thailand, stroke is the most common neurological disease resulting in hospitalization, and the third leading cause of illness after hypertension and diabetes mellitus. The prevalence of stroke in people over 20 years of age in 1983 was high (690 per 100,000), and 1.12% in people older than 60 years[4]. Currently, the number of strokes is estimated to be more than 150,000 persons per year[14]. Many people survive stroke because of access to advanced technology[3], but most of them live with impairment, disability and handicap[15]. From a Thai burden of

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disease study, stroke is the third leading cause of adult disability and disease burden[16]. The physical disability survey in 1997 found that there were 1.1 million disabled people, 13.6% of whom were paralyzed and hemiplegic[17]. In 2007, the number of disabled people increased to 1.9 million[18]. The medical cost of stroke is US$ 4,623.13 per person per year[19], or US$ 88.59 per person per month[20], US$ 114.59 per person per month for informal care cost[20], and US$ 2,025.66 for six weeks of intense rehabilitation for stroke inpatients[21] (US$ 1 = 35.185 Thai Baht at time of study).

Stroke survivors have an impairment that limits their functional performance and activities. Some also have communication difficulties and cognitive problems[22]. Therefore, sub-acute service, especially rehabilitation services, aimed at restoring functional ability is needed.

Moreover, the relationship between the medical and functional severity and the costs of care for acute and sub-acute phases of stroke are not clear. Cost of sub-acute services or rehabilitation also has not been studied in Asia[23]. Therefore, the present study examines the cost of care for acute and sub-acute phases and the relative importance of factors for predicting hospital cost of a stroke.

Material and Method

The present study was designed as a prevalence-based cost-of-illness from a provider perspective with micro-costing approach[24]. Micro-costing is a bottom-up approach based on services provided to individual patients. These data were prospectively recorded between July 2008 and March 2009. The Naresuan University Ethics Committee for Research on Humans approved the present study.

The present study was conducted in two regional 800-bed hospitals with separate rehabilitation wards of 20 beds. Udonthani Hospital is a regional hospital in the northeast and Ratchaburi Hospital is in the central part of Thailand. Both have more than 1,500 outpatient visits per day and 60,000 inpatient admissions per year. Occupancy rate is about 90%. Available rehabilitation services include physiotherapy, occupational therapy, and prostheses and orthoses. Udonthani Hospital rehabilitation department is staffed with three physical medicine and rehabilitation doctors (PM&R), seven physical therapists, three occupational therapists, three prosthetists, two outpatient nurses, and nine inpatient nurses. Ratchaburi Hospital is staffed with three PM&R doctors, eight physical therapists, three occupational therapists, five prosthetists, and nine inpatient nurses. In 2008, the outpatient rehabilitation visits to Ratchaburi Hospital were almost double those for Udonthani Hospital (229 vs. 121 visits a day). The average length of stay and bed occupancy rates of rehabilitation wards in both hospitals were similar (12.13 vs. 11.85 days and 52% vs. 50% for Ratchaburi and Udonthani Hospital respectively).

Subjects in the present study were 407 adult stroke patients older than 17 with first episode. Stroke was defined as final diagnosis based on history and clinical examination and confirmed by computerized tomography (CT) scan or magnetic resonance imaging (MRI). Patients with transient ischemic attack and subarachnoid hemorrhage were excluded. However, patients who were medically stable on admission to sub-acute and non-acute phase were all subjects whereas patients who were referred to other hospitals or died during the present study period were excluded. All eligible patients, admitted to either rehabilitation wards or general wards, were the subjects for the present study. Identification of sub-acute and non-acute phase was crucial, especially for patients admitted to general wards. The doctor's decision to refer a patient to rehabilitation services for functional restoration was used as a criterion for triggering a sub-acute phase. A checklist form was designed for doctors to record when a patient changed to sub-acute and non-acute phase. During the present study period, 503 patients were recruited with a discharge diagnosis of stroke, except transient ischemic attack (TIA). Data on all resources consumed were collected from hospital records for four categories of wards: intensive care unit, common ward, private ward, and rehabilitation ward. Resource consumption data were separately collected to distinguish activities delivered at three ward categories. Moreover, patient-level cost data were determined to reflect services provided during acute phase or sub-acute and non-acute phase from the first day of admission until discharge. Services delivered to each patient were recorded in the medical records, hospital electronic databases and activity records for nursing and rehabilitation activities. Functional status at admission to sub-acute phase as disability level was measured by Barthel index score. A patient can receive a score range from 0 to 20. The present study classified the BI score into 5 disability categories: a BI of 20 stands for independent, 15-19 mild, 10-14 moderate, 5-9 severe, and 0-4 very severe. Cognitive status was measured by Mini-Mental State Examination: Thai version (MMSE-Thai 2002) and depression was measured by Geriatric Depression Scale (Short-form).

Cost analysis

Cost in the present study confined to only provider costs. The methodology used to estimate the average costs per patient was a combination of two different approaches, the standard top-down, and the bottom-up or micro-costing methods.

The standard top-down approach was used to calculate average costs of medical services given at a cost center of the hospital. The hospital departments were classified as supporting or patient cost centers. Direct cost of each cost center was the summation of capital, material, and labor costs. The labor cost was the summation of salaries, wages, overtime payment, and fringe benefits such as home rent, health, education, and child benefits of people in each cost center. If any person worked in more than one cost centers, a proportion of working time in each department by self-report method was used to apportion the labor cost. Material costs consumed by each cost center were determined. Depreciation costs of buildings and durable goods were calculated as present value of an annuity. Costs of each cost center that provided treatment services directly to patients included direct and indirect costs. The indirect costs were allocated from administration and supporting cost centers by applying a simultaneous cost allocation method. At the end, the full cost of each medical department and wards were calculated by summing capital, material, and labor costs both direct and indirect cost.

Bottom-up or micro-costing approach provided cost data based on treatments given to each individual patient. Micro-costing was more appropriate for cost study at cost centers producing heterogeneous products. Eighteen categories of services according to reimbursement schedules of the Civil Servant Medical Benefit Scheme[25] were adopted for this micro-costing. This approach determined both direct and indirect costs. Direct costs of medical services provided to patients at a number of cost centers were estimated from the ratio of cost-to-charge (RCC) and the recorded charge data (*e.g.* drugs, laboratory, radiology, operation, special medical investigations, blood, instrument and prosthesis devices, acupuncture and alternative medical treatments, medical equipment, dental service). Nursing and rehabilitation service costs were estimated from the relative value unit (RVU) of each activity, the number of activities given to a patient from admission until discharge and the cost of one RVU. This is because a service that is twice as costly as another is assigned a relative value twice as high as that of the comparison service[26]. Costs per occupied bed-day were added as indirect costs based on lengths of stay in any of four ward categories.

Cost of inpatient services for stroke was prospectively collected on each patient between July 2008 and February 2009. Resource consumption of each patient was identified and divided into two phases of care, acute and sub-acute phases. A full cost of each patient was computed by summing the costs of 18 service categories.

Descriptive statistics such as frequency, mean, and standard deviation were employed to explain cost of hospital, cost per service type, and cost per patient, cost per phase of care, and cost per person per stay. Enter multiple regression analysis was employed to analyze the relationship between inpatient cost for stroke (dependent variable) and several potential explanatory variables (independent variables such as stroke pathology, functional score at admission to sub-acute and non-acute phase measured by the Barthel Index, patient age, and length of stay, amount of rehabilitation services, and hospital). These independent variables were selected based on the result from exploration of cost of sub-acute inpatient services among stroke patients and treatment. A p-value of less than 0.05 was considered statistical significant.

Results

Patient characteristics

Of the 503 stroke patients who were admitted during the present study period, 14 died in hospital, 21 were subsequent episodes of stroke, 53 had different discharge diagnoses other than stroke, and 10 were discharged at acute phase. The final number for analysis was 407 patients (80.9% of 503). Table 1 shows that more than half of the patients were male (55.8%), the mean age was 61.5 years old, 56.0% suffered from hypertension before stroke, 49.6% had severe disability, 49.1% with cognitive problems, and 32.4% with depression. Average length of stay (LOS) was 8.1 days, with 3.1 days in acute and 5.0 days in sub-acute phase. Rehabilitation services for stroke patients included physical therapy and occupational therapy, the average number of days of physical therapy was 1.71 days, and of occupational therapy 0.83 day.

Profiles of stroke patients at two hospitals were significantly different in terms of risk factors (diabetes comorbidity, smoking, and alcohol intake habits), pathology of stroke (ischaemic or hemorrhagic), cognitive and depression status, though the laterality of weakness was not significantly different. Therefore, service profiles were significantly different for surgical

Table 1. Characteristics of stroke patients and care

Characteristics	Hospital 1 (n = 168)		Hospital 2 (n = 239)		Total (n = 407)		p-value
	Number of patients	%	Number of patients	%	Number of patients	%	
Sex							
Male	95	56.5	132	55.2	227	55.8	0.792[1]
Female	73	43.5	107	44.8	180	44.2	
Age (years)							
Age < 45	21	12.5	15	6.3	36	8.8	0.093[1]
Age 45-54	28	16.7	38	15.9	66	16.2	
Age 55-64	51	30.4	71	29.7	122	30.0	
Age 65-74	38	22.6	65	27.2	103	25.3	
Age ≥ 75	30	17.9	50	20.9	80	19.7	
Risk factors							
Hypertension	98	58.3	130	54.4	228	56.0	0.430[1]
Diabetes**	25	14.9	63	26.4	88	21.6	0.006[1]
Hyperlipidaemia	11	6.5	21	8.8	32	7.9	0.409[1]
Heart disease	12	7.1	17	7.1	29	7.1	0.991[1]
Smoking**	54	32.1	108	45.2	162	39.8	0.008[1]
Alcohol intake*	59	35.1	111	46.4	170	41.8	0.023[1]
Functional status							
BI score 0-4 (very severe)	85	50.6	117	49.0	202	49.6	0.679[1]
BI score 5-9	44	26.2	55	23.0	99	24.3	
BI score 10-14	25	14.9	48	20.1	73	17.9	
BI score 15-19	9	5.4	14	5.9	23	5.7	
BI score 20 (normal)	5	3.0	5	2.1	10	2.5	
Cognition**							
Cognitive problems	104	61.9	96	40.2	200	49.1	0.000[1]
Good cognition	64	38.1	143	59.8	207	50.9	
Depression**							
Depressed	75	44.6	57	23.8	132	32.4	0.000[1]
Mild	34	20.2	134	56.1	168	41.3	
No	59	35.1	48	20.1	107	26.3	
CT Scan/MRI							
No	14	8.3	18	7.5	32	7.9	0.767[1]
Yes	154	91.7	221	92.5	375	92.1	
Pathology							
Ischaemic	65	38.7	148	61.9	213	52.2	0.000[1]
Haemorrhagic	102	60.7	24	10.0	126	31.1	
Unspecified	1	0.06	67	28.1	68	16.7	
Surgery							
% in ischaemic	1	1.5	3	2.0	4	1.9	0.000[1]
% in haemorrhagic	43	42.2	4	16.7	47	37.3	
Side of weakness							
Left	67	39.3	91	38.1	157	38.6	0.652[1]
Right	101	60.7	148	61.9	254	61.4	

** $p < 0.01$, * $p < 0.05$

[1] Chi-square test

[2] Student's t-test statistic

Table 1. (cont.)

Characteristics	Hospital 1 (n = 168)		Hospital 2 (n = 239)		Total (n = 407)		p-value
	Mean	SD	Mean	SD	Mean	SD	
Patient's age (years)	60.7	13.0	62.0	12.6	61.5	12.8	0.381[2]
Length of stay (days)							
Acute phase**	5.2	7.0	1.7	1.8	3.1	5.0	0.000[2]
Sub-acute phase**	7.6	9.3	3.1	3.9	5.0	7.0	0.000[2]
Whole admission**	12.8	11.6	4.8	4.7	8.1	9.2	0.000[2]
Inpatient rehabilitation (days)							
Physical therapy	1.57	3.74	1.80	1.85	1.71	2.79	0.418[2]
Occupational therapy	0.72	2.87	0.90	1.26	0.83	2.08	0.392[2]

** $p < 0.01$, * $p < 0.05$

[1] Chi-square test

[2] Student's t-test statistic

rates, LOS in acute and sub-acute phases, but not for access to diagnostic computerized tomography (CT) scan or magnetic resonant imaging (MRI). It should be noted that the earlier delivery of rehabilitative services (physical and occupational therapy) in Hospital 2 was offset by the shorter LOS, hence the total number of days of rehabilitation services in both hospitals were not significantly different.

Rehabilitation services in sub-acute phase

Table 2 presents details of rehabilitation services in sub-acute phase by initial Barthel Index score or disability level. Rehabilitation services in this study focused on activities related to functional improvement of stroke patients such as balance, limb, activity of daily living (ADL), ambulation, and gait trainings, according to literature review and expert opinion[22,27]. The most frequent activities included ADL, sensory motor components, balance and gait trainings. The patterns of rehabilitation services delivered at the two hospitals were mostly significantly different, but were the least different for stroke patients with severe disability level. Overall, Table 2 shows the higher the disability level the higher the intensity of rehabilitation services in both hospitals.

Inpatient service cost for stroke

Total cost of Hospital 1 was 1300.4 million Baht (US$ 1 was 34.129 Thai Baht)[28]. This consisted of 37% labor cost, 50% material cost, and 13% capital cost. Total cost of Hospital 2 was 1660 million Baht, with 35% labour cost, 54% material cost, and 11% capital cost. Average total cost of the rehabilitation in both hospitals was 29.8 million Baht with 26% labor cost, 55% material cost, and 19% capital cost. The proportion of rehabilitation service cost was less than 3% of total hospital cost. Bed-day costs were approximately 320 Baht per day for general ward in both regional hospitals, 541 Baht per day for private ward, and 965 Baht per day for ICU. Bed-day costs in rehabilitation ward varied from 309 Baht per day at Hospital 1 and 448 Baht per day at Hospital 2.

Table 3 presents inpatient stroke cost with details on acute and sub-acute phases. Average cost per admission was 32,372 Baht. Average cost of acute phase was higher than sub-acute phase (51,031 Baht vs. 19,256 Baht). Cost per bed-day in acute phase was 5,546 Baht, whereas for sub-acute phase was 3,039 Baht. Cost of sub-acute phase and costs per bed-day of acute and sub-acute phases were significantly different between the hospitals. Costs of younger stroke patients were higher than costs of older patients. Cost of hemorrhagic stroke (65,340 Baht) was higher than cost of ischaemic stroke (18,949 Baht). In addition, costs of all phases were significantly different among stroke pathology.

Cost of acute and sub-acute care related to disability level

Table 4 summarizes average sub-acute service cost of stroke among initial disability level by BI score. It shows the relationship between costs and disability levels measured by Barthel index. The average costs were significantly different among disability levels in all phases of care. In general, the more disabled the more costly (except the cost of sub-acute phase for very severe disability was lower than cost of severe disability in hospital 2). Average cost of very severe disability per admission was the highest (45,812 Baht) whereas average cost of no disability was the lowest

Table 2. Rehabilitation services provided to stroke patients by initial disability level, mean (standard deviation)

Activities	Very severe (BI 0-4)			Severe (BI 5-9)			Moderate (BI 10-14)			Mild (BI 15-19)			Total		
	Hosp1 (n = 85)	Hosp2 (n = 117)	p-value	Hosp1 (n = 44)	Hosp2 (n = 55)	p-value	Hosp1 (n = 26)	Hosp2 (n = 28)	p-value	Hosp1 (n = 8)	Hosp2 (n = 14)	p-value	Hosp1 (n = 163)	Hosp2 (n = 234)	p-value
ROM exercise	0.16 (1.13)	1.06 (1.98)	0.000	0.07 (0.33)	1.05 (1.87)	0.001	0.00 (0.00)	0.85 (1.17)	0.000	0.00 (0.00)	0.57 (0.94)	0.104	0.10 (0.82)	0.99 (1.75)	0.000
Balance training	0.47 (2.49)	1.91 (1.96)	0.000	1.20 (2.87)	1.58 (1.85)	0.431	1.15 (3.31)	1.46 (1.50)	0.588	0.00 (0.00)	1.07 (0.83)	0.002	0.73 (2.65)	1.68 (1.79)	0.000
Upper limb training	0.58 (2.08)	1.37 (1.61)	0.003	1.11 (3.19)	1.49 (1.86)	0.464	1.00 (3.09)	1.35 (1.55)	0.512	0.00 (0.00)	0.64 (0.93)	0.067	0.78 (2.56)	1.35 (1.62)	0.006
Lower limb training	0.58 (2.08)	1.38 (1.64)	0.002	1.00 (3.13)	1.49 (1.86)	0.335	1.00 (3.09)	1.38 (1.54)	0.487	0.00 (0.00)	0.64 (0.93)	0.067	0.75 (2.54)	1.36 (1.64)	0.003
ADL training	1.31 (4.04)	1.95 (1.95)	0.135	1.59 (3.40)	1.55 (1.84)	0.933	1.19 (3.12)	1.48 (1.49)	0.594	0.00 (0.00)	1.00 (0.88)	0.005	1.30 (3.60)	1.70 (1.78)	0.145
Ambulation training	0.00 (0.00)	1.49 (0.97)	0.000	0.20 (0.79)	1.58 (1.85)	0.000	0.19 (0.80)	1.44 (1.62)	0.000	0.00 (0.00)	0.93 (0.83)	0.005	0.08 (0.52)	1.47 (1.73)	0.000
Gait training	0.54 (2.42)	0.89 (1.34)	0.193	0.86 (2.15)	1.33 (1.75)	0.240	0.42 (1.30)	1.44 (1.65)	0.008	0.00 (0.00)	1.00 (0.88)	0.005	0.60 (2.15)	1.12 (1.49)	0.004
Home program	0.88 (2.91)	1.88 (2.02)	0.004	0.82 (1.90)	1.53 (1.84)	0.063	0.50 (1.27)	1.56 (1.58)	0.004	0.00 (0.00)	1.07 (0.83)	0.002	0.75 (2.34)	1.68 (1.83)	0.000
Self care training	0.00 (0.00)	0.70 (0.97)	0.000	0.05 (0.30)	0.67 (0.79)	0.000	0.04 (0.20)	0.79 (1.30)	0.005	0.00 (0.00)	0.36 (0.84)	0.249	0.02 (0.19)	0.70 (1.00)	0.000
Sensory motor components training	1.22 (5.50)	1.21 (1.98)	0.986	1.32 (4.80)	1.04 (1.25)	0.677	1.85 (7.10)	1.65 (2.44)	0.859	0.00 (0.00)	0.71 (1.14)	0.094	1.29 (5.38)	1.23 (1.90)	0.883
Home programme	0.00 (0.00)	0.42 (0.85)	0.000	0.00 (0.00)	0.35 (0.64)	0.001	0.00 (0.00)	0.58 (1.27)	0.022	0.00 (0.00)	0.36 (0.63)	0.130	0.00 (0.00)	0.44 (0.90)	0.000

Excluded stroke patient with normal (BI score 20, n = 10)
p-value < 0.05 (student's t-test statistic)

Table 3. Cost of medical services among stroke groups (Baht/case)

	Average cost per acute phase (SD) (n = 407)	Average cost per sub-acute phase (SD) (n = 407)	Average cost per admission (SD) (n = 407)
Hospitalization**			
Hospital 1	31,188 (47,354)	20,726 (34,094)	51,914 (60,868)
Hospital 2	9,231 (13,266)	10,392 (15,133)	19,623 (24,588)
Total/case	18,294 (33,804)	14,658 (25,265)	32,952 (46,170)
Cost (Baht/day)			
Hospital 1	6,077 (5,028)	2,783 (1,507)**	4,121 (2,695)
Hospital 2	5,548 (3,325)	3,242 (1,347)**	4,141 (1,623)
Total/case	5,761 (4,099)	3,039 (1,436)**	4,133 (2,129)
Age (years)			
< 45	18,568 (26,530)	22,969 (32,738)	41,537 (42,883)
45-54	25,128 (45,478)	15,830 (21,383)	40,958 (55,544)
55-64	17,932 (33,160)	15,181 (35,148)	33,113 (51,472)
65-74	14,971 (25,316)	12,841 (16,685)	27,818 (33,341)
≥ 75	17,351 (35,957)	11,491 (11,421)	28,848 (44,391)
Pathology**			
Ischaemic	8,946 (11,904)	10,238 (13,712)	19,184 (20,654)
Haemorrhage	40,653 (52,280)	26,159 (39,061)	66,812 (66,856)
Unspecified	6,061 (2,131)	7,098 (7,407)	13,159 (8,216)
Sex			
Male	18,326 (34,164)	12,403 (15,984)*	30,729 (40,820)
Female	18,254 (33,438)	17,501 (33,327)*	35,755 (52,126)

** $p < 0.01$ (student's t-test statistic)

Table 4. Cost of acute and sub-acute phases of stroke by initial disability level, mean (standard deviation)

Initial BI score or disability level	Average cost (Baht/case) acute phase (SD)**			Average cost (Baht/case) sub-acute phase (SD)**			Average cost (Baht/case) acute and sub-acute (SD)**		
	Hosp1	Hosp2	Total	Hosp1	Hosp2	Total	Hosp1	Hosp2	Total
Very severe (BI score 0-4)	47,777 (59,226)	10,506 (14,264)	26,190 (43,859)	28,894 (44,991)	14,225 (19,612)	20,397 (33,476)	76,671 (74,034)	24,731 (30,887)	46,587 (59,177)
Severe (BI score 5-9)	12,588 (15,286)	9,605 (17,473)	10,931 (16,522)	12,793 (12,277)	7,673 (7,608)	9,948 (10,226)	25,381 (22,955)	17,278 (19,716)	20,879 (21,486)
Moderate (BI score 10-14)	14,034 (14,839)	6,613 (4,333)	9,221 (10,011)	13,841 (14,359)	6,376 (8,067)	8,999 (11,197)	27,875 (20,276)	12,989 (10,125)	18,219 (16,062)
Mild (BI score 15-19)	27,427 (46,460)	7,018 (4,296)	14,440 (28,843)	8,020 (7,929)	4,874 (3,886)	6,018 (5,719)	35,447 (51,369)	11,892 (7,252)	20,457 (32,352)
Normal function (BI score 20)	8,054 (5,517)	6,599 (3,212)	7,327 (4,324)	7,835 (7,342)	4,605 (1,850)	6,220 (5,327)	15,889 (5,916)	11,204 (4,775)	13,546 (5,638)
Total	31,188 (47,354)	9,231 (13,266)	18,294 (33,804)	20,726 (34,094)	10,392 (15,133)	14,658 (25,265)	51,914 (60,868)	19,623 (24,588)	32,952 (46,170)

** $p < 0.01$ (student's t-test statistic)

(13,023 Baht). In sub-acute phase, average cost of very severe disability was 20,397 Baht and average cost of stroke with no disability (Barthel scores 20) was 6,220 Baht.

Predictors of medical cost for sub-acute service

Table 5 presents determinants of cost of stroke at acute and sub-acute phases. Since the cost was not normally distributed, a natural logarithmic

Table 5. Predictors of direct medical cost (ln cost) of acute and sub-acute phases

	Acute phase		p-value	Sub-acute		p-value
	B	SE		B	SE	
(Constant)	8.428	0.135	0.000	7.352	0.181	0.000
Length of stay	0.088	0.006	0.000	1.033	0.044	0.000
Hospital 1	0.046	0.060	0.444	-0.395	0.071	0.000
Barthel index	-	-	-	-0.017	0.005	0.001
Physical therapy	-	-	-	0.035	0.011	0.001
Male	0.007	0.048	0.882	-0.136	0.053	0.010
Surgery	1.082	0.091	0.000	-0.198	0.094	0.037
Haemorrhage	0.444	0.090	0.000	0.202	0.101	0.047
Patient age	0.001	0.002	0.519	0.003	0.002	0.197
Cognitive problem	0.070	0.050	0.161	-0.061	0.057	0.285
Ischaemic	0.106	0.068	0.121	-0.016	0.076	0.830

Adjusted R^2 = 0. 761 (acute), 0.752 (sub-acute), probability of F-test = 0.000 (acute and sub-acute)
SE = standard error

transformation was undertaken. Independent variables came from patients' characteristics, rehabilitation service, and cost analysis in tables 1 to 4. The fitted model for acute medical cost was slightly better than the model for sub-acute cost (adjusted R^2 = 0.755, the probability of F-test = 0.000 and the Durbin-Watson value for test of independence of the residual was 1.902 for acute care model and adjusted R^2 = 0.748. The probability of F-test = 0.000 and the Durbin-Watson value was 1.881 for sub-acute care model). The predicting variables for the acute care model were length of stay, hemorrhage, and surgery. Two more predicting variables for cost of sub-acute phase were physical therapy and Barthel score at admission to sub-acute phase. Scatter plots of residuals against predicted values and all independent variables showed no funnel shape indicating homoscesdasticity.

Discussion

The cost of care for stroke patients consists of cost during acute and sub-acute phases in hospitals. Neither hospital in the present study had a stroke unit. All patients were admitted to general medicine or neurology wards until discharge. A few patients were transferred to rehabilitation wards. The average cost per case of hospital 1 was higher than that of hospital 2 because a higher proportion of cases at hospital 1 were hemorrhagic stroke, underwent higher surgical treatment, and stayed in hospital longer in both acute and sub-acute phases. Moreover, average cost per bed-day in sub-acute phase was significantly different between the two hospitals. This finding confirms the results of studies on cost for stroke in Europe. The results show that the cost of stroke care varies across Europe because of differences in unit costs, length of stays and resource use[29,30]. The results also showed that hospital characteristics significantly affected cost of care such as CT, MRI, surgical treatment in acute phase, and rehabilitation services in sub-acute phase. Definition of stroke in the present study was based on final diagnosis as confirmed by CT or MRI (91% of all subjects were diagnosed by CT or MRI). The difference in surgical treatments (42% of hemorrhagic stroke in hospital 1 and 17% in hospital 2) may be explained by availability of neurosurgeons. In addition, the difference of rehabilitation services in sub-acute phase, despite the same disability level, may be explained by differences in responses to consultations, hospital policy and clinical guidelines for stroke treatment. This is the first study to compare rehabilitation service intensity by Barthel index score across hospitals in the absence of a routine monitoring system of Barthel index. It raises the question whether the higher intensity of rehabilitation services would lead to more improvement in functional status. The present study clearly shows that cost of the sub-acute phase was influenced by the intensity of rehabilitation services.

The difference in stroke characteristics (ischaemic vs. hemorrhagic) between the two hospitals contrasted with most studies that showed that 70% to 80% of strokes were cerebral infarctions[2,31,32]. Findings

from Japan and Australia support that the medical cost in acute phase for cerebral hemorrhage was higher than cerebral infarction[32,33]. Patient demographic characteristics in the present study played diverse roles in predicting cost of acute and sub-acute phases. Age had no impact on the costs of both phases of care, but male patients had significantly lower costs in sub-acute phase compared to females. The average cost of women was higher than men in a Canadian study indicating that strokes in men cost less than in women[34]. Moreover, the study of Job et al supported that the more severe disability, the higher cost of care after stroke[35]. Finally, the associations of impaired cognitive status and depression at admission to sub-acute phase and cost, as seen in Table 1, are similar to the classifications of the Case-Mix Group that gives higher resource weight to patients with cognitive problems than to patients with normal cognitive function[36]. In addition, rehabilitation treatment may extend to community and the cost of sub-acute phase in hospital had the largest impact on total cost over the first year after stroke as presented in a Swiss study[37]. The minimal cost of rehabilitation services in the present study of less than 5% of the total cost contrasted to a previous study showing cost of rehabilitation was higher for stroke patients[38]. This may be explained by the fact that the two hospitals in the present study were acute hospitals with less focus on rehabilitation services. However, the cost was similar to the hospital-based study of acute ischemic stroke in Japan[12].

The present study employed two main approaches to patient level costing: top-down and micro-costing, the primary technique for studying cost of health service[39]. Top-down approach used total hospital financial data and allocated costs down to the departmental level. The micro-costing approach obtains accurate cost data according to resources consumed per individual patient. Because of limited standard cost information for hospitals in Thailand, the relative value unit cost driver for nursing and rehabilitation service was used for calculating resource consumption for costing per activity[26]. In the heterogeneous cost centers, such as pharmacy and laboratory, the detailed bill and cost-to-charge ratio (RCC) of individual services was used to calculate patient level costs with reasonable accuracy and ease of implementation[40]. The RCC approach was the standard method for examining average cost per diagnosis-related group (DRG)[41]. Findings from multiple regressions supported the fact that wide cost variations were found in different stroke characteristics, number of days of hospital stay, and hospital services. Casemix payment system is recommended for prospective payment based on average costs of a large number of patients with similar diagnoses[42-45]. The present cost study was made possible under a larger study of sub-acute and non-acute casemix classification. Inferring the results of this study to represent all one thousand hospitals in Thailand is not recommended, as the present study covered only two regional hospitals.

Stroke is the most common cause of hospitalization among neurological diseases, and the third ranked source of disease burden in Thailand, Malaysia[46], and elsewhere. The ageing population is associated with a rise in incidence of stroke and economic burden[2]. The present study showed high access to advanced technology (90% of cases with CT scan), hence the number of stroke survivors increased as a result of accurate and early diagnosis followed by appropriate treatment[47,48]. However, even with the availability of advanced technology and facilities, 60% of stroke cases die or become dependent[49]. Cost of care for stroke was high but economic burden of stroke was higher, accounting for direct, indirect, and intangible cost[23]. The cost of stroke care in the US was estimated at US$ 57.9 billion annually[50]. With limited budget, practitioners and the number of hospital beds for rehabilitation service in Thailand[51], the present study further showed that cost of rehabilitation service was less than 10% of the total hospital cost in contrast to a Germany study that showed cost of rehabilitation service for stroke accounted for 37%[52].

Conclusion

Stroke patients' costs in the two regional hospitals were influenced by the characteristics of stroke patients, hospital treatments, and phases of care. Acute phase was shorter but with higher cost per bed-day, hence had higher total costs than sub-acute phase. Predictors of cost in acute phase included surgery, hemorrhagic pathology, and length of stay. Additional predictors of costs in sub-acute phase included initial Barthel index, patient gender, rehabilitation treatment (physical therapy), and the hospital. Hemorrhagic stroke results in higher cost of both acute and sub-acute phases. However, surgical treatment increased cost in acute phase but reduced cost in sub-acute phase. Length of stay was relatively important in predicting cost of sub-acute phase but less important in predicting cost of acute phase of stroke.

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Potential conflicts of interest

None.

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ต้นทุนระยะเฉียบพลันและกึ่งเฉียบพลันของผู้ป่วยโรคหลอดเลือดสมอง

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ภูมิหลัง: *โรคหลอดเลือดสมองเป็นโรคที่เป็นปัญหาทางสาธารณสุขและเป็นปัญหาใหญ่ที่ทำให้เกิดการสูญเสียอย่างมหาศาลทางด้านเศรษฐกิจของโลก*

วัตถุประสงค์: *เพื่อศึกษาต้นทุนในมุมมองของผู้ให้บริการและปัจจัยที่มีผลต่อต้นทุนของการรักษาพยาบาลผู้ป่วยโรคหลอดเลือดสมองในระยะเฉียบพลันและกึ่งเฉียบพลัน*

วัสดุและวิธีการ: *เป็นการศึกษาต้นทุนบนพื้นฐานของความชุกของโรคด้วยวิธีจุลภาคจากผู้ป่วยหลอดเลือดสมองรายใหม่จำนวน 407 ราย โดยการเก็บข้อมูลต้นทุนแบบไปข้างหน้าระหว่างเดือนกรกฎาคม พ.ศ. 2551 ถึงเดือนมีนาคม พ.ศ. 2552*

ผลการศึกษา: *ต้นทุนเฉลี่ยในการนอนโรงพยาบาล 1 ครั้ง เท่ากับ 32,372 บาท โดยต้นทุนการรักษาพยาบาลในระยะเฉียบพลันสูงกว่าระยะกึ่งเฉียบพลัน ซึ่งต้นทุนมีความแตกต่างกันเมื่อระดับความพิการต่างกัน ปัจจัยที่มีผลต่อต้นทุนในระยะเฉียบพลันคือการผ่าตัด พยาธิสภาพที่มีเลือดออกที่สมอง วันนอนโรงพยาบาล (adjusted $R^2 = 0.755$; $p < 0.001$) ส่วนปัจจัยที่มีผลต่อต้นทุนในระยะกึ่งเฉียบพลันคือระดับความพิการที่ประเมินด้วยเครื่องมือบาร์เทล อินเด็กส์ เพศ การฟื้นฟูสมรรถภาพทางการแพทย์ และโรงพยาบาล (adjusted $R^2 = 0.748$; $p < 0.001$)*

สรุป: *คุณลักษณะของผู้ป่วย พยาธิสภาพของโรค การรักษา และระยะของการรักษา (ระยะเฉียบพลันและกึ่งเฉียบพลัน) ควรนำไปพิจารณาในนโยบายการจัดสรรงบประมาณเพื่อชดเชยการบริการสำหรับผู้ป่วยโรคหลอดเลือดสมอง*