COST OF ACUTE CARE FOR ISCHEMIC STROKE IN THAILAND

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Abstract. Stroke is a leading cause of mortality and morbidity worldwide and has a large economic cost. The hospital-associated cost for acute treatment is a major component of the annual cost for stroke. In this study, we aimed to determine the direct medical costs of acute ischemic stroke treatment per patient admitted to a tertiary level government hospital in Bangkok, Thailand and to identify components of and predictors for the costs in order to better estimate the overall cost of stroke in Thailand. We retrospectively reviewed the records and direct medical costs for treatment of 335 patients admitted to the study hospital with ischemic stroke during 2008. Year 2008 prices were used for the study. We used multiple regression analysis to determine factors associated with hospital cost. The mean cost for acute ischemic stroke treatment per patient at the study hospital was 42,400 Thai Baht (USD 1,211). The largest proportion of the cost was for the hospital room and routine services (57%) followed by imaging (23%). The average length of stay was 5.7 days. Multiple linear regression analysis of the natural log of the direct medical cost showed variation in costs were largely attributable to: the Barthel Index on admission, the time of onset of stroke symptoms, stroke unit admission, rtPA usage, development of severe complications, patient history of smoking and to presence of two demographic factors (gender and whether the patient had health insurance or not) (R-square = 0.4135). This study determined the total hospital cost for acute ischemic stroke treatment and the factors associated with this cost. This can provided information to get a better estimate of the overall cost of stroke in Thailand.

Keywords: stroke, cost of illness, hospital costs, health care costs, cerebrovascular disorders

INTRODUCTION

Cerebrovascular disease (stroke) is the second most common cause of death worldwide and is a leading cause of physical disability in the elderly (Brainin *et al*, 2007). It is responsible for about 2% of total healthcare costs (Dodel *et al*, 2004; Cadilhac *et al*, 2010). In developing countries, the mortality rate from stroke is high and accounts for over two-thirds of global stroke related deaths. Several factors limit stroke care in developing countries, such as limited healthcare resources,

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accessibility of healthcare, socioeconomic considerations and societal beliefs about stroke (Feigin, 2005).

In Thailand, stroke was the leading cause of death in women and the third leading cause of death in men in 2004 (Bundhamcharoen *et al*, 2011). A 2005 stroke epidemiology study found the prevalence of stroke in Thailand to be 2.46% among those aged > 40 years (Poungvarin, 2007). Another study from Thailand found the prevalence of stroke among those aged > 60 years to be 1.12% in 1998 (Viriyavejakul *et al*, 1998). It is estimated that there are around 150,000 new cases of stroke per year in Thailand (Poungvarin, 2007). The most common type of stroke in Thailand is ischemic stroke (Poungvarin *et al*, 2002; Poungvarin, 2007; Suwanwela *et al*, 2007; Archongka *et al*, 2008).

The total burden of stroke is expected to increase over time. This is due to trends in risk factors, such as hypertension, diabetes mellitus, hypercholesterolemia, and smoking in the Thai population (Piravej and Wiwatkul, 2003). This will result in higher overall healthcare costs for investigations and treatment. Therefore, it is important to determine the economic impact of stroke. Studies of the economic impact of stroke have been conducted worldwide (Claesson *et al*, 2000; Dewey *et al*, 2001; Chang and Tseng, 2003; Yoneda *et al*, 2003; Dodel *et al*, 2004; Cadilhac *et al*, 2009; Saka *et al*, 2009; Wei *et al*, 2010). Two systematic reviews of the economics of stroke (Luengo-Fernandez *et al*, 2009; Demaerschalk *et al*, 2010) pointed out the majority of cost-related analyses focused on short-term in-hospital care because of its important impact on the annual cost of stroke.

Given the pressure on healthcare resource allocation, it is essential for policy makers to understand the burden of disease. It is important to determine cost of illness (COI) measuring the value of resources used to treat ischemic stroke in the short- and long-term. Few studies concerning cost of stroke has been performed in Thailand. One study conducted in 1998 before healthcare reform in Thailand (Youngkong *et al*, 2004) focused on the cost to society of cerebral infarction. This study was conducted under the former health insurance system prior to the introduction of universal coverage. Another study (Moongkhetklang, 1999) evaluated the patient financial cost but not the economic cost. Another study explored the unit cost for a stroke rehabilitation program (Archongka *et al*, 2008). The purpose of the present study was to determine the hospital cost of treatment per patient of acute ischemic stroke in Thailand.

MATERIALS AND METHODS

We retrospectively reviewed the charts of acute ischemic stroke patients admitted during January to December, 2008 to the Prasat Neurological Institute (PNI), a tertiary level hospital specialized in neurology in Bangkok, Thailand.

Patient selection

Inclusion criteria were a patient aged ≥ 45 years admitted to the hospital with an acute ischemic stroke (ICD10 code: I63) with onset of symptoms within 7 days of admission. Exclusion criteria were other diagnoses, patients aged ≤ 45 years and those with incomplete medical records.

Study design

A prevalence-based cost of illness analysis was used for the study to estimate economic burden of the treatment of acute stroke. Resource utilization for each patient during hospitalization was obtained by reviewing the medi-

cal records and hospital database. Unit cost analysis per stroke case at the study hospital was conducted using a standard costing or traditional costing approach to determined costs of each cost center in the study hospital. The departments of the study hospital were categorized into 32 production cost centers and 15 supporting cost centers. The direct cost for each center included labor, material and capital costs. The indirect cost for each production cost center was allocated from the supporting cost centers through the simultaneous allocation method using appropriate allocation criteria. The average method was used to calculate unit cost for out-patient department costs, hospital room costs and routine service costs for each ward. The total costs for each cost center were divided by the number of patients admitted to each ward. The cost to charge ratios (CCR) for the pharmacy, laboratory, rehabilitation and radiological departments were explored from the total costs for each department divided by total revenues or charges for each department. The CCRs of each department were used to calculate the costs for pharmacy services, laboratory tests, rehabilitation services and radiological services.

Clinical evaluation

Baseline data collected included patient socioeconomic status, stroke characteristics and stroke risk factors. These data were obtained from the patient medical records. Socioeconomic demographics consisted of age, gender, residence, marital status and presence and type of health insurance. Stroke characteristic data collected included the type of stroke (first-ever or recurrent), the time of onset of stroke symptoms and stroke severity on admission as measured by the Glasgow Coma Scale and Barthel Index (BI) score. The BI score is a measure of dependence on others for activities of daily living, ranging from 0-100, with a low number signifying more dependent and a higher number signifying less dependent. Stroke was defined as major if the BI score was ≤ 70 and minor if the BI score was > 70 (Caro *et al*, 2000). Risk factors for stroke, such as diabetes, hypertension, dyslipidemia, smoking and alcohol use were recorded. The stroke outcome at discharge was recorded as the length of stay (LOS) and the BI score.

Economic cost

The cost of treatment was considered from the healthcare provider perspective. Total direct medical costs included hospital room and routine service costs, imaging costs, special investigation costs, medication costs, medical supply costs, and rehabilitation service costs. Hospital room and routine service costs were calculated by multiplying the LOS by the unit cost of hospital room and routine service per patient-day for each ward in the Department of Neurology at the study hospital. Other costs were calculated by multiplying the patient's expenses obtained from the hospital bill of payment by the CCR of each item in the hospital bill. This cost analysis was using 2008 prices and recorded the costs in Thai Baht (THB). All costs were rounded to the nearest THB 10.

Statistical analysis

Descriptive statistics were used to summarize socioeconomic characteristics, stroke characteristics and stroke risk factors. Direct medical costs were expressed as means with standard deviations and medians with ranges. Univariate analysis was performed to test for differences in the total direct costs. The Mann-Whitney *U* test and the Kruskal-Wallis test were used to test for differences in the total direct costs for each group. The Wilcoxon

rank test was used to compare the severity of the stroke on admission with the severity at discharge. Multivariate linear regression analysis was performed to assess the influence of explanatory variables on total direct medical costs and explore the cost function of acute stroke care. Several potential explanatory variables were selected based on previous studies (Mamoli *et al*, 1999; Caro *et al*, 2001; Evers *et al*, 2002; Chang and Tseng, 2003; Wei *et al*, 2010). The studied variables were: 6 demographic variables (gender, age, marital status, area of residence, type of health insurance), 7 variables related to stroke risk factors (first-ever or recurrent stroke, dyslipedimia, hypertension, diabetes, patient history of smoking and alcohol and number of risk factors) and 6 variables related to stroke characteristics (onset of stroke symptoms, BI on admission, receiving recombinant tissue plasminogen activator (rtPA) and stroke fast tract care, stroke unit admission and severe complication during admission). Robust standard errors of coefficients were calculated.

To estimate the economic effect of each studied variable on the cost of stroke care, the cost function for acute stroke care was obtained from the significant factors on multiple regression analysis. The predicted costs for stroke care per admission were calculated from the cost function of stroke care. The predicted costs was re-transformed from logarithms to natural units (THB) using the Duan smearing factor for re-transformation bias correction (Duan, 1983; Buntin and Zaslavsky, 2004). All statistical tests were performed as two-sided tests and a p-value <0.05 was considered statistically significant. All statistical analyses were conducted with STATA 10.1 (StataCorp LP, College Station, TX).

Ethical considerations

The study was approved by the institutional review board of Prasat Neurological Institute.

RESULTS

Patients characteristics and service utilization

A total of 335 ischemic stroke patients were included in our study. The mean (±SD) age was 64 (±10) years; 145 (43%) were female. Seventy percent of studied subjects had either Civil Servant Medical Benefit Scheme (CSMBS) or Universal Coverage (UC) health insurance coverage. The average (±SD) BI score measuring severity of ischemic stroke on admission was 62.3 (±28.0). Of the 335 total patients, 176 (52.5%) had a major deficit in activities of daily living (BI ≤ 70). About three quarters of the study subjects were admitted to hospital with a first-ever stroke and 79% had more than one stroke risk factor. Dyslipidemia was the most common risk factor (74.6%) among study subjects (Table 1).

Of the 335 study subjects, 131 (39%) were admitted to the regular neurological ward, 107 (32%) were admitted to the stroke unit and 97 (29%) were admitted initially to the stroke unit, and subsequently transferred to the regular neurological ward. Overall, the average length of stay (LOS) was 5.70 (±5.65) days. The mean LOS for subjects admitted to the stroke unit (3.48 days) was shorter than for those admitted to the regular neurological wards (6.76 days) and who stayed in both the stroke unit and the regular neurological ward (6.70 days) ($p = 0.0001$).

Twenty-two patients (6.57%) were admitted to the hospital within 3 hours of the onset of stroke symptoms. Fourteen patients (4.17%) were treated with the

Table 1
Patient characteristics (n=335).

Demographic data	% or Mean±SD
Gender	
Female	43.3%
Male	56.7%
Mean age in years	64.10±10.28
Area of living	
In Bangkok	58.8%
Others	41.2%
Married	74.6%
Type of health insurance	
CSMBS	53.7%
Out-of-pocket	29.3%
Universal Coverage	17%
Stroke characteristics	
Time from onset of stroke symptoms (days)	2.68±2.16
Arrival within 3 hours of onset	6.6%
Recurrent stroke	23.6%
Glasgow Coma Score	14.51±1.29
Barthel Index Score on admission	62.28±28.00
Stroke risk factors	
Dyslipidemia	74.6%
DM	30.4%
HT	65.4%
Smoking	29.6%
Alcohol	26.3%
>1 risk factor	78.8%

CSMBS, Civil Servant Medical Benefit Scheme; DM, diabetes mellitus, HT, hypertension.

stroke fast track protocol and nine patients (2.69%) were given intravenous rtPA. Fifty-two patients (15.5%) experienced at least one severe complication. These complications included urinary track infection (4.18%), pneumonia (3.58%), progressive stroke (1.49%), bedsores (1.49%), sepsis (1.19%), seizures (1.19%), renal failure (0.9%), gastrointestinal bleeding (0.9%) and cerebral edema (0.30%).

In-hospital mortality among the study patients was 2 patients (0.6%). The mean BI score at discharge was 76.90 (±25.97) and the average BI score change from admission to discharge was 14 (±17) (p<0.0001). Two hundred twenty-seven patients (68%) had a minor deficit in activities of daily living or independence (BI = 70-100) at discharge.

Unit cost for stroke care

In 2008, the total economic cost for ischemic stroke care at the study hospital was 776.6 million Thai Baht (THB) (approximate THB35 = USD1). The total cost was comprised of material costs (59%), labor costs (23%) and capital costs, cost of hospital buildings and medical equipments (18%). The highest cost for

Table 2
Direct medical costs.

Itemized direct medical costs	Mean (±SD) in THB	Median (range) in THB	Composition of total cost (%)
Hospital room and routine service costs	24,010 (±15,430)	21,720 (13,590-28,970)	56.62
Imaging costs	9,670 (±12,220)	6,930 (6,930-6,930)	22.88
Special investigations costs	2,840 (±3,080)	840 (420-4,380)	6.70
Medication costs	2,330 (±5,540)	610 (240-2,210)	5.50
Pharmacy service costs	340 (±810)	90 (30-320)	0.80
Laboratory costs	2,570 (±1,860)	1,960 (1,480-2,620)	6.06
Rehabilitation costs	520 (±650)	420 (0-680)	1.23
Medical supply costs	90 (±540)	0 (0-40)	0.21
Total direct medical costs	42,400 (±26,400)	36,350 (24,850-48,860)	100%

THB, Thai Baht.

hospital room and routine services per patient-day was in the stroke unit, which is a specialized ward for stroke care. The cost for the stroke unit per patient-day (THB7,420) was 2.43 times higher than the average unit cost per patient-day for the regular neurological ward (THB 2,975). The cost-to-charge ratios (CCR) for imaging, laboratory testing, rehabilitation and medication at the study hospital were 2.07, 1.73, 1.40 and 0.8, respectively. The pharmacy service cost was estimated as 9% of the medication cost.

Hospital cost and cost model of acute stroke care

The mean and median direct medical costs per admission were THB42,400 and THB36,350, respectively (Table 2). The total direct medical cost consisted of the hospital room and routine service costs, including accommodations, meals, clothes, routine doctors' fees, routine nursing care fees and medical supplies for basic nursing care (56.6%), imaging costs included brain computerized tomography (CT) scan, magnetic resonance imaging (MRI) and routine x-rays (22.9%), special investigations included echocardiograms, carotid Doppler ultrasounds (6.7%), costs of medications and pharmacy service (6.3%), laboratory testing (6.1%), rehabilitation services, included physiotherapy, speech therapy and occupational therapy (1.2%) and medical supply costs (0.2%). The largest cost was the hospital room and routine service costs, followed by imaging costs (Table 2). The average daily cost per study patient was THB9,660.

Table 3 shows the mean total direct medical cost per admission and the mean total direct medical cost per day for selected demographic, disease characteristic and treatment variables. Comparison of the costs of the selected variables using univariate analysis revealed the type of health insurance and severity of stroke on admission affected the total direct medical cost. The total costs per admission of the patients who had universal coverage (UC) was higher than for those who had the Civil Servant Medical Benefit Scheme (CSMBS) and those who paid out-of pocket ($p = 0.003$). The total cost per admission and the cost per day for patients with a

Table 3
Costs by selected variables for treating acute ischemic stroke.

	Total direct medical costs in THB		Average LOS (days)	Mean Cost per day in THB
	Mean (±SD)	Median	Mean (±SD)	Mean (±SD)
All patients (*N*=335)	42,400 (±26,400)	36,350	5.7 (±5.60)	9,660 (±5,540)
Demographics				
Age in years				
<50 (*n*=30)	48,980 (±35,590)	38,320	4.9 (±2.7)	10,330 (±5,430)
50-64 (*n*=156)	42,840 (±27,800)	36,410	5.6 (±6.0)	10,140 (±6,130)
65-79 (*n*=126)	39,930 (±21,170)	37,210	6.0 (±6.1)	9,140 (±5,110)
≥80 (*n*=23)	44,360 (±28,640)	31,340	5.7 (±3.6)	8,400 (±3,030)
Gender				
Female (*n*=190)	44,250 (±30,650)	35,260	5.8 (±6.0)	9,400 (±4,640)
Male (*n*=145)	40,990 (±22,610)	36,740	5.5 (±5.1)	9,860 (±6,150)
Health insurance type				
Out-of-pocket (*n*=98)	35,480 (±20,350)	31,120	5.2 (±4.8)	8,800 (±4,830)
UC (*n*=57)	48,400 (±28,710)	37,890	5.3 (±3.1)	10,000 (±4,750)
CSMBS (*n*=180)	44,270 (±27,880)	38,730	6.1 (±6.6)	10,030 (±6,090)
Comorbidities				
No (*n*=32)	45,270 (±30,370)	38,470	6.0 (±3.7)	9,130 (±7,370)
Yes (*n*=303)	42,100 (±25,990)	36,300	5.7 (±5.8)	9,720 (±5,330)
Disease characteristics				
Type of stroke				
First-ever (*n*=256)	40,530 (±22,790)	34,700	5.2 (±4.3)	9,660 (±5,500)
Recurrent (*n*=79)	48,450 (±35,192)	38,820	7.2 (±8.5)	9,680 (±5,720)
Functional level on admission				
Major deficit (*n*=190)	47,920 (±2,890)	42,400	7.2 (±6.9)	8,650 (±4,390)
Minor deficit (*n*=145)	35,160 (±20,600)	29,750	3.8 (±2.3)	10,990 (±6,550)
Treatment				
Stroke fast tract				
No (*n*=321)	40,650 (±23,690)	35,010	5.7 (±5.7)	9,440 (±5,350)
Yes (*n*=14)	82,510 (±47,770)	76,820	6.1 (±3.4)	14,890 (±7,320)
rtPA used				
No (*n*=326)	40,490 (±23,130)	35,140	5.6 (±5.7)	9,520 (±5,390)
Yes (*n*=9)	111,620 (±42,810)	106,400	8.4 (±3.0)	14,960 (±8,400)
Treatment setting				
Regular neurological ward (*n*=133)	31,630 (±16,090)	26,560	6.8 (±7.6)	6,770 (±3,800)
Stroke Unit (*n*=107)	43,700 (±26,620)	38,220	3.5 (±2.0)	13,63- (±5,910)
Combination (Stroke Unit at initial admission) (*n*=97)	55,640 (±30,840)	46,770	6.7 (±4.5)	9,220 (±4,390)
Severe complication				
No (*n*=283)	39,580 (±23,730)	33,370	5.0 (±4.9)	9,930 (±5,510)
Yes (*n*=52)	57,760 (±34,140)	43,190	9.6 (±7.6)	8,250 (±5,590)

LOS, length of stay; THB, Thai Baht; UC, Universal Coverage; CSMBS, Civil Servant Medical Benefit Scheme; rtPA, recombinant tissue plasminogen activator.

Table 4
Cost function of acute stroke care.

	Unstandardized coefficients			95% CI of β	
	β	Robust SE	*p*-value	Lower bound	Upper bound
Female	0.119	0.058	0.039	0.006	0.233
Age	-0.002	0.003	0.386	-0.007	0.003
Married	-0.051	0.057	0.366	-0.163	0.060
Living in Bangkok	0.041	0.048	0.389	-0.053	0.135
Universal Coverage Scheme	0.217	0.081	0.007	0.057	0.376
CSMBS	0.172	0.051	0.001	0.073	0.273
Recurrent stroke	0.055	0.057	0.348	-0.060	0.171
Dyslipidemia	-0.100	0.064	0.124	-0.227	0.027
Hypertension	-0.001	0.057	0.982	-0.114	0.111
Diabetes	0.065	0.056	0.253	-0.046	0.175
Cigarette smoking	0.179	0.070	0.011	0.042	0.316
Alcohol	-0.047	0.062	0.456	-0.170	0.076
Risk factors ≥ 1	0.013	0.084	0.873	-0.151	0.178
Logarithmic onset	-0.048	0.024	0.042	-0.095	-0.002
Barthel Index on admission	-0.004	0.001	<0.001	-0.006	-0.002
Stroke fast track	-0.129	0.186	0.487	-0.496	0.237
rtPA	0.618	0.172	<0.001	0.278	0.958
Stroke Unit admission	0.382	0.051	<0.001	0.282	0.482
Severe complications	0.300	0.067	<0.001	0.167	0.432
Constant	10.487	0.238	<0.001	10.018	10.955

Model outcome was a natural log transformation of the direct medical cost. R^2 is the percentage of total variance explained by the model; = 0.4135.
Cost function, the multiple regression model explaining the variables that had an influence on the cost of acute stroke care.
CI, confident interval; CSMBS, Civil Servant Medical Benefit Scheme; rtPA, recombinant tissue plasminogen activator.

BI score < 70 on admission were more costly than those with BI score = 70-100 ($p < 0.0001$ and 0.0017, respectively).

The total direct medical costs per admission for patients who received stroke fast track care, rtPA and admission to the stroke unit were higher than the patients who did not enter the stroke fast tract ($p = 0.0001$), who did not receive rtPA ($p < 0.0001$) and who were admitted to the regular neurological ward ($p = 0.0001$).

Variables related to longer length of stay (LOS) were severity on admission ($p = 0.0001$), receiving rtPA or having thrombolysis ($p = 0.0022$), stroke unit admission ($p = 0.0001$), and having severe complications during hospitalization ($p < 0.0001$).

Multiple regression analysis explored factors associated with the total cost of acute stroke care or the cost function of acute stroke care (Table 4). The variables with a positive association with the total

Table 5
Predicted costs for stroke care by varying significant factors.

	Predicted cost in THB	Cost change in THB	Percent change from base case
Female	48,466	5,438[a]	12.64%
Cigarette smoking	51,463	8,434[a]	19.60%
Own CSMBS	43,028	6,799[b]	18.77%
Own UC	45,009	8,780[b]	24.23%
BI score on admission decreased 20 units from base case	46,612	3,584[a]	8.33%
Received rtPA	79,827	36,799[a]	85.52%
Stroke Unit admission	43,028	13,662[c]	46.52%
Severe complications	58,082	15,054[a]	34.99%

[a]An average value or median value of patient characteristics and treatments were used as base-case (THB43,028).
[b]Out-of pocket was used as base case (THB36,299).
[c]Regular neurological ward was used as base case (THB29,367).
THB, Thai Baht; UC, Universal Coverag; CSMBS, Civil Servant Medical Benefit Scheme; rtPA, recombinant tissue plasminogen activator.

cost of stroke care were gender, type of health insurance (CSMBS and UC), patient history of smoking, use of thrombolysis, admission to the stroke unit and having severe complications during hospitalization. The time from the onset of stroke symptoms and BI score on admission were negatively associated with the total cost of stroke care.

The predicted costs for stroke care based on the cost function for acute stroke care are shown in Table 5. The economic effects of each significant variable were explored by the percentage of the total cost change. The total cost change resulted from varying the variables in the model from the base-case value. Receiving an anti-thrombolytic agent increased the total cost of stroke care by 85% compared to not receiving an anti-thrombolytic agent. Patients admitted to the stroke unit had 47% higher direct medical cost than those admitted to the regular neurological ward.

DISCUSSION

Stroke care results in a large economic burden. This burden includes long-term disability and problems with activities of daily living. Acute stroke care attempts to decrease long-term disability. The prevalence and burden of stroke may rise in an aging society. Cost studies need to be conducted regularly to understand the economic impact of stroke with changing economic and new health technologies. This is important to enable policy makers to understand the costs of stroke and better allocate health care resources.

In this study, we assessed the economic burden of acute ischemic stroke care at a tertiary level hospital specializing in neurology in Thailand. The mean total direct medical cost per admission was THB42,400 (±26,400) and the mean daily cost was THB9,660 (±5,540). The mean LOS was 5.7 (±5.6) days.

In the United States, the average in-hospital cost for acute ischemic stroke care per admission has been reported to vary from USD8,000 to USD23,000 (Demaerschalk *et al*, 2010). The cost for acute ischemic stroke care reported from Europe and Australia ranged from USD9,840 to USD13,668 (Caro *et al*, 2000). The cost for acute stroke care per admission in China has been reported to be USD903 (Wei *et al*, 2010), for Pakistan to be USD1,179 (Khealani *et al*, 2003), for Taiwan to be USD1,798 (Chang and Tseng, 2003), for Singapore to be USD4,984 (Venketasubramanian and Yin, 2000) and for Japan to be USD6,887 (Yoneda *et al*, 2003). Our finding of USD1,211 per admission was in accordance with the Asian cost range. Differences in cost vary by nation based on economics, the different methodologies used to estimate cost, and the different health care systems.

The average LOS in our study (5.7 days) was remarkably shorter than other previously published studies. The average LOS for acute ischemic stroke care in Germany was 10.2 days (Dodel *et al*, 2004), in Singapore was 17 days (Venketasubramanian and Yin, 2000), and in Japan was 33 days (Yoneda *et al*, 2003). However, our findings were similar to a study from a tertiary hospital in Pakistan (5 days) (Khealani *et al*, 2003) and a community hospital in the United States (5.9 days) (Reed *et al*, 2001).

The use of thrombolytic therapy is important for early acute ischemic stroke care. rtPA is a major expenditure for early critical care of ischemic stroke in the United States (Demaerschalk *et al*, 2010). However, in our study, the cost of thrombolytic therapy did not result in a higher cost of stroke care because only 2.69% of study patients received early thrombolysis.

A breakdown of direct medical costs in our study showed the major cost component was the hospital room and routine services costs (57.6%), followed by diagnostic radiology (22.9%). These main cost components are similar to the previous international studies. In the United States, the room cost for hospitalization was 50% of the acute hospital cost for ischemic stroke (Diringer *et al*, 1999). The ward charge accounted for 38.2% of the hospital cost for stroke care in Singapore (Venketasubramanian and Yin, 2000). A study in Japan revealed 69% of the cost for acute ischemic stroke was attributable to the cost of the room and the staff (Yoneda *et al*, 2003).

Sixty percent of patients in the current study were admitted to the stroke unit, half were admitted to the stroke unit only for initial acute treatment and were then transferred to the regular neurological ward. Treatment in the stroke unit generally requires more personnel and monitoring devices. This explains the higher direct medical cost in the stroke unit than the regular neurological ward.

Only 6.57% of hospitalized patients presented to the hospital within 3 hours of symptom onset; therefore, negating the possibility of thrombolysis use. This is why only 2.69% of studied patients in this study received thrombolysis. This finding is similar to another study from Thailand (Brainin *et al*, 2007) where only 2.1% of subjects received thrombolysis.

We investigated factors that might be predictors of direct medical costs for admission by performing multiple regression analysis. Gender, type of health insurance, patient history of smoking, usage of thrombolysis, admission to the stroke unit, and having severe complications during hospitalization were all positively associated with the total cost

of stroke care. Factors negatively associated with the total cost of stroke care were the time from the onset of stroke symptoms and BI score on admission. Our multiple linear regression analysis findings are in harmony with previous studies investigating predictors of stroke care cost using the same technique. A study from China found having health insurance, stroke severity, occurrence of complications during hospitalization, age of the patient and marital status were predictors of hospitalization cost (Wei *et al*, 2010). Evers *et al* (2002) found gender, stroke severity measured by the Rankin scale, and having complications during hospitalization were predictors for total cost of hospital stay for stroke patient in the Netherlands. A cost analysis of acute care in Taiwan found the relationships between cost of acute stroke care and gender, smoking and stroke severity measured by National Institutes of Health Stroke Scale (NIHSS) (Chang and Tseng, 2003). The BI on admission was found to predict treatment costs after acute ischemic stroke (Caro *et al*, 2001).

Having health insurance influenced direct medical costs in our study. Patients with health insurance had higher costs than those who did not. Patients with a Civil Servant Medical Benefit Scheme (CSMBS) had higher acute ischemic stroke costs because they tended to receive excessive medical resources and had more tests performed than those without this scheme since their insurance paid for it without having a limit on spending or had a high payment ceiling. For patients with the UC scheme, which is financed by capitation, a reason for a higher cost for stroke care might be from caring for more severe patients referred to our tertiary care under the UC contract; these patients incurred greater medical costs due to greater disease severity. Although UC scheme covers people not having CSMBS or social security scheme (SSS) coverage, some patients who needed specialized neurological care not covered by UC declared themselves as self-pay or out-of-pocket patients, which occurred in nearly 30% of study patients.

This study had several limitations. First, the study addressed only direct medical costs. No indirect costs or costs for productivity loss, direct non-medical costs, such as traveling expenses or costs of informal care were determined in this study. Further studies of these costs are needed to give a picture of the entire problem to policy makers.

Second, most of the study patients had mild to moderate stroke and were more likely to be discharged home after having their investigations, completing acute treatment and starting rehabilitation usually within a week of admission. This skewed the group of patients examined and could lead to underestimation of the cost for managing acute ischemic stroke (Caro *et al*, 2000; Dodel *et al*, 2004).

Third, at our study hospital, we have a protocol for managing ischemic stroke. Routine examinations, include basic laboratory tests, an electrocardiogram, an electroencephalogram, a Doppler ultrasound and a CT or MRI scan are conducted on all patients. This protocol approach in study hospital consumes more resources by performing more tests than stroke care protocols at other hospitals. A specialized tertiary hospital setting results in higher labor costs, material costs and capital costs than a standard tertiary hospital and has a lower hospital occupancy rate. Our findings cannot be applied to other settings.

In conclusion, this study calculated the total hospital cost for acute ischemic stroke treatment. This information should

be valuable to estimate stroke disease burden in Thailand. The total direct medical cost per patient per hospitalization for acute ischemic stroke was THB 42,400. The hospital room costs and routine service costs accounted for the majority of costs, followed by imaging costs. Variations in cost were due mainly to the use of thrombolysis, stroke unit admission, severe complications during hospitalization and having health insurance.

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