Costs and Healthcare Resource Utilization of Inpatients with Acute Ischemic Stroke

Thitiya Khongmee, PharmD[1], Sukrisd Koowattanatianchai, MD[2], Phatsakorn Onnim, MSc[3], Nattanichcha Kulthanachairojana, PhD[3]

[1] Department of Pharmacy, Chonburi Hospital, Thailand; [2] Division of Cardiology, Department of Medicine, Burapha Hospital, Burapha University, Chonburi, Thailand; [3] Department of Social and Administrative Pharmacy, Faculty of Pharmaceutical Sciences, Burapha University, Chonburi, Thailand

Objective: Acute ischemic stroke treatment costs are a concerning issue in developing countries. The objective of the present study was to determine cost and health-care resource utilization in patients with acute ischemic stroke in Thailand.

Materials and Methods: The present study was a retrospective cohort study. The authors reviewed data from the electronic medical records of acute ischemic stroke patients. Data on resource utilization and healthcare costs (HCCs) were collected. Cost data, patient characteristics, and disease severity were described. Analyses were conducted using generalized linear regression models with a log-link and gamma distribution.

Results: Two thousand two hundred seventy-eight patients had been diagnosed with ischemic stroke. The mean total costs per patient were 1,244.40 (±594.81) USD. Medical equipment was the most significant cost for acute ischemic stroke patients. Patients suffering from moderate-to-severe stroke had higher HCCs than those suffering from minor stroke. Multivariate generalized linear modeling presented age, gender, most comorbidities, and the Barthel index score on admission to affect total cost in patients with acute ischemic stroke.

Conclusion: HCCs in patients with acute ischemic stroke were significantly associated with age, gender, some comorbid conditions, and the Barthel index score at admission. HCCs are rising as a result of the severity of strokes.

Keywords: Acute ischemic stroke, Healthcare resource utilization, Healthcare costs, Thailand

Stroke is a sudden onset of neurological dysfunction resulting from a disruption of blood supply to the brain, retina, or spinal cord. This disturbance can occur due to a blockage in a blood vessel (ischemic stroke) or bleeding into the brain tissue (hemorrhagic stroke). Stroke symptoms often persist for more than 24 hours, but even brief symptoms may be categorized as a stroke if medical imaging, such as computerized tomography or magnetic resonance imaging, or an autopsy confirmed evidence of focal infarction or hemorrhage that correlated with the symptoms[1].

Ischemic strokes account for about 62% of all strokes worldwide, causing a considerable number of fatalities and disabilities and becoming a major global health concern[2]. Treatment of an ischemic stroke during the acute phase is essential for minimizing brain damage and maximizing the patient's chance of recovery. Furthermore, the expense associated with this treatment can frequently strain healthcare budgets[3].

Due to the difference in healthcare systems between low- and middle-income nations, the cost of a stroke might vary significantly. The severity of the stroke is the most influential cost factors[4]. The severity of stroke can be assessed using various tools, with the National Institutes of Health Stroke Scale (NIHSS) and Barthel index (BI) being two widely recognized measures. The NIHSS is typically utilized to evaluate the degree of neurological impairment, while the BI is commonly used to assess the patient's ability to perform basic activities of daily living (ADL). By providing valuable information on different aspects of the patient's condition, these scales can aid in determining the severity of stroke and developing a suitable treatment plan[5].

In Thailand, the Division of Non-Communicable

Correspondence to:

Kulthanachairojana N.

Department of Social and Administrative Pharmacy, Faculty of Pharmaceutical Sciences, Burapha University, Chonburi 20130, Thailand.

Phone: +66-82-6963561

Email: nattanichcha@go.buu.ac.th

Diseases within the Ministry of Public Health has reported an upward trend in stroke incidents during the past three years, between 2016 and 2018. Each year, there were more than 300,000 recorded cases of stroke and more than 30,000 stroke-related deaths[6]. This tendency has placed a substantial load on the national budget and healthcare costs (HCCs).

The main issue in developing countries is the high expense of HCCs. As a result, developing treatment cost models will aid the creation of efficient health policy. The previous study discussed the proportion of HCCs and factors associated with HCCs in acute ischemic stroke treatment in Thailand[7]. However, no study has reported healthcare resource utilization (HCRU) and HCCs by stroke severity. The purpose of the present study was to investigate the HCCs and HCRU of acute ischemic stroke patients in Thailand.

Materials and Methods
Study population
The present study was the retrospective cohort study. The authors reviewed the electronic medical records of patients admitted for acute ischemic stroke according to ICD 10. All patients admitted to Chonburi Hospital between January 1, 2016 and December 31, 2020 with a first-ever acute ischemic stroke diagnosis were included. Recurrent stroke patients, transient ischemic attack patients, and the patients with incomplete clinical records were excluded.

Data collection
The authors collected demographic data, including age, gender, comorbidity, and disease severity. Disease severity was defined at admission as a stroke characteristic measured by the NIHSS and BI score[8,9]. A thorough medical history was obtained, including a medical and neurological examination. The present study protocol was approved by the Chonburi Hospital Institutional Review Board, number 8/64/T/h3. All procedures performed in the present study were in accordance with the Helsinki Declaration.

Healthcare costs and healthcare resources utilization
HCCs and HCRU were categorized into nine groups as 1) drugs, 2) laboratories, 3) medical equipment, 4) hospital rooms and routine services, 5) rehabilitation, 6) radiology, 7) medical procedures, 8) blood transfusion, and 9) artificial organs. The calculations included each category of HCCs and

Table 1. Demographic characteristic

Demographic data	n=2,278
Age (year); mean±SD	65.45±14.75
Sex; n (%)	
Male	951 (41.75)
Female	1,327 (58.25)
Comorbidity; n (%)	
Hypertension	1,466 (64.35)
Dyslipidemia	620 (27.22)
Diabetes mellitus	431 (18.92)
Atrial fibrillation	345 (15.14)
Ischemic heart disease	127 (5.58)
Chronic kidney disease	142 (6.23)
Stroke characteristic; mean±SD	
NIHSS on admission	7.21±3.62
Barthel index score on admission	54.47±21.30

NIHSS=National Institutes of Health Stroke Scale; SD=standard deviation

HCRUs during admission. The cost-to-charge ratios were used to calculate HCCs. The authors used healthcare resources to calculate the proportions of the patient's usage. HCCs were analyzed by disease severity as defined by the NIHSS score. Stroke severity was categorized as minor stroke 1 to 4, moderate stroke 5 to 15, and moderate to severe stroke 16 to 20[8]. The costs of care per patient by demographic characteristic were calculated. The cost was converted from Thai Baht to USD using the exchange rate of 33.05 Baht to 1 USD, which was the exchange rate for January 16, 2023.

Statistical analysis
Descriptive statistics were used to evaluate the demographic and stroke characteristics. HCRU were described by percentage. HCCs were described by disease severity, demographics, and stroke characteristics. A generalized linear regression model with a log-link and gamma distribution was used for the analysis of HCCs, and a p-value of less than 0.05 was considered statistically significant. The models used demographic characteristics, stroke characteristics, and comorbidity as covariates. All statistical analyses were performed using Stata Statistical Software, version 17 (StataCorp LLC, College Station, TX, USA).

Results
Demographic and clinical characteristics
Two thousand two hundred seventy-eight patients had been diagnosed with acute ischemic stroke. The mean age was 65.45 years, and 58.25%

Table 2. Proportions of acute ischemic stroke patients using healthcare resources

Healthcare resources	Healthcare resources usage; n (%)			
	All types	Minor stroke	Moderate stroke	Moderate to severe stroke
Drug	2,278 (100)	426 (100)	1,725 (100)	127 (100)
Laboratory	2,278 (100)	426 (100)	1,725 (100)	127 (100)
Medical equipment	2,278 (100)	426 (100)	1,725 (100)	127 (100)
Hospital room and routine service	2,278 (100)	426 (100)	1,725 (100)	127 (100)
Rehabilitation	903 (39.64)	170 (39.91)	696 (40.35)	37 (29.13)
Radiology	474 (20.81)	96 (22.54)	348 (20.17)	30 (23.62)
Medical procedure	2,278 (100)	426 (100)	1,725 (100)	127 (100)
Blood transfusion	111 (4.87)	22 (5.16)	81 (4.70)	8 (6.30)
Artificial organ	1,090 (47.85)	204 (47.89)	827 (47.94)	59 (46.46)

Table 3. Healthcare cost of acute ischemic stroke patients

Healthcare costs	Cost (USD); mean±SD			
	All types (n=2,278)	Minor stroke (n=426)	Moderate stroke (n=1,725)	Moderate to severe stroke (n=127)
Drug	141.16±306.94	100.27±215.19	139.77±308.51	297.21±462.46
Laboratory	190.56±125.43	172.44±87.94	190.81±131.48	247.74±131.53
Medical equipment	380.66±137.53	376.86±208.01	377.18±113.01	440.63±131.53
Hospital room and routine service	349.95±39.63	349.99±43.24	348.65±39.06	367.38±29.64
Rehabilitation	10.04±9.65	10.05±9.72	9.87±9.60	12.25±9.75
Radiology	77.00±151.49	52.61±131.98	73.98±149.21	199.75±184.40
Medical procedure	72.49±123.54	61.35±102.55	71.07±121.60	129.10±185.30
Blood transfusion	1.88±8.65	1.71±8.18	1.84±8.58	2.91±10.80
Artificial organ	21.10±107.43	14.14±17.93	21.00±93.04	45.78±297.06
Total cost	1,244.40±594.81	1,139.47±500.90	1,233.63±582.10	1,742.80±788.67

SD=standard deviation

were female. The three most common comorbidities were hypertension (64.35%), dyslipidemia (27.22%), and diabetes mellitus (18.92%). Stroke characteristics were described by the NIHSS and BI score on admission. The mean NIHSS and BI scores were 7.21 and 54.47, respectively. Table 1 presents the demographic and stroke characteristics of the patients.

Healthcare resource utilization and healthcare costs

Table 2 shows the proportion of healthcare resource usage for all the patients as well as broken down for the three types of acute ischemic stroke patients as minor, moderate, and moderate to severe. Table 3 and 4 presents the HCCs of acute ischemic stroke patients by stroke severity and demographic characteristics. The mean total cost per patient for all types of patients was 1,244.40 (±594.81) USD. The mean treatment costs for stroke severity were 1,139.47 (±500.90) USD, 1,233.63 (±582.10) USD, and 1,742.80 (±788.67) USD for minor, moderate,

and moderate to severe strokes, respectively. The major portions of the total direct medical cost of patients with acute ischemic stroke were medical equipment (30.59%), hospital room and routine service (28.12%), and laboratory testing (15.31%). Medical equipment included medical supplies and medical devices such as bubble traps, reservoirs, cardiotomy suction, vents, and hemofiltration. For patients with a more severe stroke, there was an increase in HCCs compared to patients with a minor stroke. Table 4 shows a comparison of the cost of care per patient by demographic characteristic. Patients who were older, male, had an underlying disease, and had a more severe stroke were found to have higher cost of stroke treatment. Generalized linear modeling with a gamma distribution and log-link was used to assess the importance of covariates such as age, gender, comorbidity, and stroke severity (Table 5). Age, gender, and comorbidities such as hypertension, dyslipidemia, diabetes mellitus, atrial fibrillation, and the BI Score on admission were found to be significant predictors of HCCs.

Table 4. Comparison of cost of care per patient by demographic characteristic

Demographic data	Cost per patient (USD) mean±SD
Age (year)	
<60	1,225.35±643.02
60 and above	1,254.36±567.96
Sex	
Male	1,263.55±567.06
Female	1,230.68±613.77
Comorbidity	
Hypertension	
• Yes	1,227.32±575.98
• No	1,275.25±626.55
Dyslipidemia	
• Yes	1,199.39±524.51
• No	1,261.23±618.36
Diabetes Mellitus	
• Yes	1,301.07±654.87
• No	1,231.18±579.29
Atrial fibrillation	
• Yes	1,595.22±688.50
• No	1,181.78±553.78
Ischemic Heart Disease	
• Yes	1,717.11±1,025.32
• No	1,216.49±546.91
Chronic kidney disease	
• Yes	1,349.05±642.17
• No	1,237.44±591.03
Stroke severity	
Minor stroke (NIHSS 1 to 4)	1,139.47±500.91
Moderate stroke (NIHSS 5 to 15)	1,233.63±582.10
Moderate to severe stroke (NIHSS 16 to 20)	1,742.80±788.67

NIHSS=National Institutes of Health Stroke Scale; SD=standard deviation

Discussion

The present study determined HCCs and HCRU in patients with acute ischemic stroke at a tertiary-level hospital in Thailand. HCCs and HCRU were described and analyzed according to the stroke severity and demographic characteristics of the patients. The present study demonstrated the association between total HCCs and stroke severity and the demographic characteristics of the patients. The mean total of the patients was 1,244.40 (±594.81) USD per admission. A significant portion of the total direct medical cost of patients with acute ischemic stroke was accounted for by medical equipment.

The majority of the previous study's total direct medical costs were hospital room and routine service costs, imaging costs, and special investigations costs[7]. In contrast, for the acute ischemic stroke patients in the present study, the major expenses were medical equipment, hospital rooms and routine services, and laboratory testing. This may be due to the longer length of stay in the previous study and the different treatment protocol of each hospital. The present study's mean cost was higher than the previous study[7].

The cost of care per patient by demographic characteristic in the present study showed that, on average, older patients, male gender, and patients with more comorbidities such as dyslipidemia, diabetes mellitus, atrial fibrillation, ischemic heart disease, chronic kidney disease, and stroke severity had higher HCCs. This evidence was also found in the USA and Germany[10-12]. This increase in HCCs is due to a prolonged stay and higher HCRU[10,13].

The authors investigated several factors that may be predictors of HCCs. The previous study in Thailand showed female gender, BI on admission, and

Table 5. Multivariate generalized linear modelling

Factors	Coefficient (SE)	Relative increase in costs associated with variable (baseline=1)	p-value
Age	0.0578 (0.0158)	3.64	<0.001
Male	–0.0064 (0.0015)	–4.11	<0.001
Hypertension	0.1989 (0.0522)	3.81	<0.001
Dyslipidemia	–0.0997 (0.0174)	–5.72	<0.001
Diabetes mellitus	–0.1769 (0.0761)	–2.32	0.020
Atrial fibrillation	0.2863 (0.1453)	1.97	0.049
Ischemic heart disease	0.4171 (0.0367)	11.36	<0.001
Chronic kidney disease	–0.0207 (0.0307)	–0.67	0.501
NIHSS on admission	–0.0017 (0.0149)	–0.12	0.908
Barthel index score on admission	–0.0109 (0.0005)	–19.53	<0.001
Constant	7.9669 (.1936)	41.14	<0.001

NIHSS=National Institutes of Health Stroke Scale; SE=standard error

severe complications associated with higher HCCs in patients with acute ischemic stroke[7]. In addition, the authors found an association between HCCs and age and comorbidities, such as hypertension, dyslipidemia, diabetes mellitus, atrial fibrillation, and ischemic heart disease. In the present study, the NIHSS found no statistically significant findings for HCCs, but BI found statistically significant findings. It might be that BI is more detailed in scale than NIHSS. Further studies are needed to study the association between the NIHSS and the HCCs of the patients.

Since the present study was a retrospective study, the limitations were the incomplete recorded data and uncontrolled factors. Additionally, extra expenses for patient-paid external hospitalization were not included in the overall costs.

Acute ischemic stroke is the leading cause of hospitalization and caregiver burden in HCCs and HCRU. The overall hospital expense for treating an acute ischemic stroke was determined in the present study. Estimating the HCCs and HCRU of stroke disease in Thailand will provide important information for policymakers and healthcare professionals, to help them develop effective interventions to improve the quality of care for the patients and to reduce the economic burden on the healthcare system.

Conclusion

HCCs of patients with acute ischemic stroke were significantly associated with age, gender, and comorbidities such as hypertension, dyslipidemia, diabetes mellitus, atrial fibrillation, and ischemic heart disease, as well as the BI score on admission. HCCs are increasing in stroke severity. Medical equipment was the most significant cost for acute ischemic stroke patients.

What is already known on this topic?

Acute ischemic stroke is a cause of death and physical disability. HCCs of stroke are increasing over time in Thailand. HCCs of acute ischemic stroke are varied among countries.

What this study adds?

HCC of patients with acute ischemic stroke were associated with age, gender, comorbidity, and the BI score on admission. HCCs are increasing in stroke severity. Medical equipment was the main expenditure for acute ischemic stroke patients.

Conflicts of interest

The authors declare no conflicts of interest.

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