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ORIGINAL REPORT

FACTORS PREDICTING THE TOTAL MEDICAL COSTS ASSOCIATED WITH FIRST-EVER ISCHAEMIC STROKE PATIENTS TRANSFERRED TO THE REHABILITATION WARD

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Objective: **To investigate the predictors of total medical costs for first-ever ischaemic stroke patients transferred to the rehabilitation ward from the acute ward.**
Patients: **A total of 311 first-ever ischaemic stroke patients (mean age 68.9 (standard deviation (SD) 12.2) years).**
Methods: **Data, including common complications and medical events, from July 2002 to June 2012 were collected retrospectively from a regional hospital in Taiwan in order to study the potential predictors for medical costs. Significant variables from univariate analysis were included in a stepwise multivariate linear regression analysis.**
Results: **The mean total medical cost per patient was USD 4,606.80 (SD 2,926.10). The significant predictors for cost were days of total stay (coefficient: 70.3; 95% confidence interval (CI) = 56.4–84.3), impaired consciousness (coefficient: 1,031.3; 95% CI = 490.8–1,571.8), hypoalbuminaemia in the acute ward (coefficient: 2,045.1; 95% CI = 1,054.6–3,035.7), fever (coefficient: 927.0; 95% CI = 193.3–1,660.7), hypokalaemia (coefficient: 2,698.4; 95% CI = 660.5–4,736.4), and hyponatraemia (coefficient: 1,123.3; 95% CI = 72.2–2,174.5) in the rehabilitation ward (R^2 = 0.416).**
Conclusion: **These findings can help clinicians to identify risk factors for total medical costs in these patients and reduce costs by minimizing some complications (hypoalbuminaemia, fever, hypokalaemia, and hyponatraemia).**

Key words: medical cost; ischaemic stroke; rehabilitation.

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INTRODUCTION

Stroke is a major health problem worldwide. Its consequences include decreased physical activities (1) and social participation (2). The imperative need for effective preventive therapy, early critical care, and rehabilitation after an acute stroke episode often result in high levels of medical expenditure (3). As the costs for the care of acute stroke patients rise (4, 5), identifying the factors that could significantly predict the overall medical costs of treating acute stroke has become increasingly urgent. The predictors for the cost of acute stroke have been discussed in several reports in the past (6–9). Total hospital costs for acute stroke patients were then correlated mainly with length of stay (6, 8–10), stroke severity (6, 8, 9), male gender (9), female gender (4), age ≥65 years (7), atrial fibrillation (7, 9), dysphagia (11), and experienced ≥1 in-hospital complications (6).

Inpatient rehabilitation at the acute stage has been proven to improve independence after treatment (12), to decrease disability at discharge (13), and to decrease long-term costs (14) for stroke patients. Acute stroke patients using inpatient rehabilitation services include those receiving rehabilitation programmes in the acute ward (and eventually discharged from the acute ward), and those transferred to the rehabilitation ward to continue a rehabilitation programme for a prolonged period of time. Although only 34% of patients with acute stroke in Taiwan have utilized in-patient rehabilitation services (15), Chang et al. (16) used cost-effectiveness analysis for stroke management and found that the neurology/rehabilitation wards formed the optimal care model for the management of first-ever ischaemic stroke patients. In Taiwan, the Bureau of National Health Insurance (BNHI) manages a single-payer National Health Insurance (NHI) programme. However, higher-cost NHI claims for single-time hospitalization were reviewed in detail by BNHI to determine whether they were appropriate, and some claims (which BNHI might not have paid for) were sent back to the medical institution if BNHI considered them inappropriate. In case of higher medical costs for acute stroke patients transferred to the rehabilitation ward, the manager of the institution, or even the clinicians of these patients, may also face the problem of claim rejection by NHI. Previous studies discussing the factors affecting medical costs of acute stroke have not focused on the patients transferred to the rehabilitation ward from the acute ward. Considering that ischaemic

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stroke patients were the majority of stroke cases, we aimed to design a study that could provide clinicians with information to identify risk factors for medical costs and predict medical costs for first-ever ischaemic stroke patients transferred to the rehabilitation ward from the acute ward. The objective of this study was to retrospectively investigate the predictors of total medical costs for these patients.

Stroke complications frequently occur during a period of stay in the acute ward (17) and during transfer to the rehabilitation ward (18) in the acute stage. As mentioned above, experiencing ≥ 1 in-hospital complications (6) is one of the main factors known to increase the costs associated with treating acute ischaemic stroke patients. A previous study showed that the costs of hospitalization for patients with acute stroke with pneumonia were significantly higher than for those without pneumonia (19). On the other hand, the effects of various other common complications or medical events on the total medical costs of acute stroke patients remain unclear. For stroke patients admitted to the rehabilitation ward, medical complications are known to significantly correlate with length of stay, which is also associated with medical costs (20). We hypothesized that particular complications or medical events significantly influence the total medical costs, and these were also selected as potential factors for analysis.

MATERIAL AND METHODS

Enrolment of patients

The electronic medical records of patients admitted to the rehabilitation department at a regional hospital in south-central Taiwan between July 2002 and June 2012 were retrospectively reviewed. The patients considered for this study met the following inclusion criteria: (*i*) being diagnosed with acute first-ever ischaemic stroke according to the World Health Organization's (WHO) criteria definition of stroke (21); (*ii*) being transferred to the rehabilitation ward from the acute ward during the first-time stroke hospitalization; (*iii*) being eventually discharged from the rehabilitation ward after transfer to the rehabilitation ward. The study protocol (number: 100-3662B) was approved by the Institutional Review Board for Human Studies of the regional hospital.

Demographic and expense data

The demographic data, including gender (4, 9) and age (7), were analysed. Medical costs incurred during hospitalization generally included diagnosis fees, ward fees, tube feeding fees, laboratory fees, X-ray fees, therapeutic procedure fees, surgical fees, rehabilitation fees, haemodialysis fees, blood/plasma fees, anaesthesia fees, special materials fees, drugs fees, dispensing service fees, psychiatric treatment fees, and injection service fees. In the present study, the total medical costs were defined as the sum of both the NHI claims and co-payment for first-time stroke hospitalization (both in the acute ward and the rehabilitation ward), and this information for each patient was obtained from the hospital's management information system. The NHI claims are the costs that the hospital asks the BNHI to pay; the co-payment is the costs that the patient should pay. The costs were expressed as USD. The New Taiwan Dollar to USD exchange rate was calculated according to the exchange rate on the day (2 December 2013) that the statistical analysis was performed.

Medical data and rehabilitation information

In terms of the medical factors potentially affecting the costs associated with treatment, the medical history of the patient was considered, including hypertension (7), diabetes mellitus (DM) (7), hyperlipidaemia (7), atrial fibrillation (7, 9), sites of brain lesion (7) (left, right, or bilateral), stroke-induced impaired consciousness (6, 8, 9), stroke-induced dysphagia (11), and length of total stay (days) (6, 8–10) (including days in both the acute and rehabilitation wards). Hypertension was defined as the hypertension diagnosed by a clinician prior to the stroke, or systemic blood pressure of > 160 mmHg and/or diastolic blood pressure of > 95 mmHg on 2 separate occasions. DM was defined as fasting plasma glucose of ≥ 126 mg/dl or random plasma glucose of ≥ 200 mg/dl. Hyperlipidaemia was defined as a fasting cholesterol level of ≥ 200 mg/dl or a fasting triglyceride level of ≥ 150 mg/dl. Atrial fibrillation was defined as a continuous or paroxysmal arrhythmia and shown as the absence of P waves, with disorganized electrical activity in their place, and irregular R–R intervals due to irregular conduction of impulses to the ventricles on electrocardiogram. Stroke-induced impaired consciousness was defined as a Glasgow Coma Scale (GCS) score < 15 after stroke during the entire course of hospitalization. Stroke-induced dysphagia was defined as difficulty in swallowing food or liquids, and was diagnosed after examinations or bedside tests were performed by a physiatrist.

Frequently occurring complications or major medical events during the acute stroke phase (18), including upper gastrointestinal bleeding (UGIB), fever, depression, seizure, shoulder pain, hyponatraemia, hypokalaemia, and hypoalbuminaemia, were also recorded. Complications or major medical events in the acute and rehabilitation wards were considered independent events, because patients with complications or experiencing medical events in the acute ward were treated prior to transfer to the rehabilitation ward. UGIB was defined as either episodes of bloody nasogastric aspirate or ulcers, or erosions or bleeding source proven by oesophagogastroduodenoscopy. Fever was defined as any episode of body temperature > 38°C. Depression was diagnosed by a psychiatrist when the symptoms met the fourth edition of Diagnostic and Statistical Manual of Mental Disorders criteria for depression. Seizure was defined as any episode of partial or generalized convulsion and was diagnosed by a neurologist. Shoulder pain was defined as any cause, such as capsulitis, shoulder subluxation, impingement syndrome, rotator cuff injury, and shoulder–hand syndrome, which may induce shoulder pain. Hyponatraemia was defined as any record of serum sodium levels < 134 mEq/l, hypokalaemia as any record of serum potassium levels < 3.6 mEq/l, and hypoalbuminaemia as any record of serum albumin levels < 3.5 g/dl.

The rehabilitation programme offered services provided by both physical and occupational therapists. Speech therapists were also available if required. Each of the daily physical and occupational therapy sessions usually lasted more than 50 min (approximately 1 h) during weekdays. Speech therapy was carried out twice a week, and the therapy session was approximately 1 h each time.

Statistical analysis

SPSS 12.0 for Windows was used for statistical analyses. Pearson's correlation was used to evaluate the correlations between total medical costs and the continuous variables. A *t*-test was performed to evaluate the differences in total medical costs for patients with and without categorical variables. A p-value of < 0.05 was considered statistically significant. Significant independent variables were selected using univariate analysis, and these were included in a stepwise multivariate linear regression analysis in order to identify the most important risk factors for total medical costs. The collinearity of independent variables was also checked.

RESULTS

Of the 719 patients analysed, 568 were first-ever stroke patients transferred to the rehabilitation ward from the acute ward and eventually discharged from the rehabilitation ward. After

Table I. *Clinical characteristics of all patients*

	Patients
Total, *n* (%)	311 (100)
Male, *n* (%)	137 (44.1)
Age, years, mean (SD)	68.9 (12.2)
Acute ward stay, days, mean (SD)	23.3 (11.9)
Rehabilitation ward stay, days, mean (SD)	25.3 (12.0)
Total stay, days, mean (SD)	48.6 (19.2)
Total medical cost, USD, mean (SD)	4,606.8 (2,926.1)
Impaired consciousness, *n* (%)	118 (37.9)
Dysphagia, *n* (%)	205 (65.9)
Hypertension, *n* (%)	240 (77.2)
Diabetes mellitus, *n* (%)	144 (46.3)
Hyperlipidaemia, *n* (%)	120 (38.6)
Atrial fibrillation, *n* (%)	47 (15.1)
Brain lesion, *n* (%)	
Left	151 (48.6)
Right	152 (48.9)
Bilateral	8 (2.5)

SD: standard deviation.

Table II. *Potential factors for total medical cost by univariate analysis*

Predictive factors	Cost, USD/r Mean (SD)	*p*-value
Demographic data		
Male (*n*=137)	4,386.7 (2,807.2)	0.240
Age	−0.015	0.790
Total stay	0.556	<0.001
Medical history		
Impaired consciousness (*n*=118)	5,743.6 (3,438.7)	<0.001
Dysphagia (*n*=205)	5,134.5 (3,064.6)	<0.001
Hypertension (*n*=240)	4,683.9 (3,034.1)	0.394
Diabetes mellitus (*n*=144)	4,473.3 (2,991.7)	0.456
Hyperlipidaemia (*n*=120)	4,679.4 (2,872.8)	0.730
Atrial fibrillation (*n*=47)	4,847.7 (2,338.8)	0.541
Brain lesion		
Left brain (*n*=151)	4,564.2 (2,849.9)	0.803
Right brain (*n*=152)	4,602.3 (3,018.6)	0.979
Bilateral brain (*n*=8)	5,499.4 (2,762.2)	0.383
Complications or medical events occurring in the acute ward		
UGIB (*n*=35)	6,350.1 (3,186.0)	<0.001
Fever (*n*=98)	5,943.9 (3,371.2)	<0.001
Depression (*n*=47)	4,410.2 (2,199.1)	0.618
Seizure (*n*=8)	6,138.0 (3,580.4)	0.134
Shoulder pain (*n*=14)	5,102.8 (2,250.5)	0.517
Hyponatraemia (*n*=25)	6,278.0 (4,482.1)	0.003
Hypokalaemia (*n*=67)	5,402.8 (3,553.2)	0.012
Hypoalbuminaemia (*n*=23)	7,294.6 (4,502.5)	<0.001
Complications or medical events occurring in the rehabilitation ward		
UGIB (*n*=50)	5,986.3 (3,656.2)	<0.001
Fever (*n*=46)	6,100.0 (3,008.6)	<0.001
Depression (*n*=24)	5,190.0 (2,251.0)	0.310
Seizure (*n*=3)	6,743.8 (5,653.2)	0.204
Shoulder pain (*n*=81)	4,967.7 (2,561.8)	0.197
Hyponatraemia (*n*=20)	6,850.6 (2,863.3)	<0.001
Hypokalaemia (*n*=5)	8,059.5 (6,818.2)	0.008
Hypoalbuminaemia (*n*=7)	6,584.2 (3,207.3)	0.070

r: Pearson correlation coefficient; SD: standard deviation; UGIB: upper gastrointestinal bleeding.

excluding 257 patients with first-ever haemorrhagic stroke, a total of 311 first-ever ischaemic stroke patients were enrolled in the study, as shown in Table I.

Table II shows the results of the correlations between the total cost and the continuous variables (age and days of total stay). Twelve variables (total number of days of stay, impaired consciousness, dysphagia, UGIB in the acute ward, fever in the acute ward, hyponatraemia in the acute ward, hypakalaemia in the acute ward, hypoalbuminaemia in the acute ward, UGIB in the rehabilitation ward, fever in the rehabilitation ward, hyponatraemia in the rehabilitation ward, and hypokalaemia in the rehabilitation ward) identified from univariate analysis were used for multivariate regression analysis. Six of these (total number of days of stay, impaired consciousness, hypoalbuminaemia in the acute ward, fever in the rehabilitation ward, hypokalaemia in the rehabilitation ward, and hyponatraemia in the rehabilitation ward) were significantly correlated with the total medical costs and are shown in Table III.

DISCUSSION

Six predictors of the total medical costs for the patients in our study were identified and, except for impaired consciousness, they are all adjustable, treatable, or correctable. The total number of days of stay can significantly predict the total medical costs. Length of stay is also a solid factor influencing the total hospital cost for acute stroke patients who were not transferred to the rehabilitation ward (6, 8–10), and for those post-stroke patients admitted to hospitals to receive rehabilitation treatment (20, 22). The mean length of stay varies from 6 (9) to 33 (8) days in the acute ward. For acute stroke patients admitted to the rehabilitation ward, the mean length of stay ranged from 24 (23) to 34.7 (24) days. In our study, the mean length of stay was 23.3 days in the acute ward and 25.3 days in the rehabilitation ward; in both cases, the length of stay was within the previously described range. Using the total number of days of stay as a predictor for total medical costs appears to be sort of a circular reasoning, as

Table III. *Results of multivariate linear regression analysis for predictors related to the total medical cost (R^2=0.416)*

Dependent variable	Independent variable	Coefficient (B)	95% CI	*p*-value
Total cost (USD)	Total stay, days	70.3	56.4–84.3	<0.001
	Impaired consciousness	1,031.3	490.8–1571.8	<0.001
	Hypoalbuminaemia in the acute ward	2,045.1	1,054.6–3035.7	<0.001
	Fever in the rehabilitation ward	927.0	193.3–1660.7	0.013
	Hypokalaemia in the rehabilitation ward	2,698.4	660.5–4736.4	0.010
	Hyponatraemia in the rehabilitation ward	1,123.3	72.2–2174.5	0.036

CI: confidence interval.

a significant part of the medical costs consists of regular costs incurred during the hospital stay; the total number of days of stay therefore becomes a significant predictor.

Under NHI, clinicians need to set a reasonable hospital stay for inpatients because the length of stay cannot be extended indefinitely without reason. However, unpredictable causes might prolong the total hospital stay, and hence the cost associated with it (e.g. waiting in the acute ward for transfer to an available rehabilitation bed, or waiting for a transfer to a destination after discharge (nursing home, home, or another medical institution)). A previous study showed that approximately 35.6% of stroke patients admitted to the rehabilitation ward experienced delays during discharge (25). The main reasons for these delays were caregiver-related factors or organizational factors (e.g. waiting for nursing home transfer) (25). Constructing an efficient discharge planning programme for patients may solve the problems related to discharge delays and would help decrease the associated expense.

The rehabilitation fees could not be separated from the total costs in our study. According to a study by Tang et al. (10) in Taiwan, rehabilitation fees spent on physical therapy, occupational therapy, and speech therapy in the rehabilitation ward at a regional hospital was approximately USD 32.5 per day, accounting for 36.7% of the total daily cost (USD 86.4) (10). In the Kuptniratsaikul's multicentre study (23), the cost related to rehabilitation procedures was estimated to be 33.2% of the total cost for stroke patients admitted to the rehabilitation ward. Previous articles illustrated that the rehabilitation fees charged in the acute ward for stroke inpatients represented only approximately 7% (8, 9) of the total acute hospital costs. It seemed that the percentage of rehabilitation fees were higher in the rehabilitation ward (compared with total costs incurred in the rehabilitation ward) than those in the acute ward (compared with total costs incurred in the acute ward). In addition to more intensive care, medical procedures or examinations may be performed in the acute ward, which should be expected to significantly increase the total costs. We believe that future studies should focus on individually identifying predictors for medical costs and rehabilitation fees in acute stroke patients who received rehabilitation in the acute ward and the rehabilitation ward.

According to Wei et al. (6), severe GCS score (defined as 3–8) on admission was a predictor for the cost in acute stroke patients. Following Wei et al., GCS was used as a marker for stroke severity in our study. We provide evidence that the stroke severity with any impaired consciousness, i.e. without the highest GCS score, after stroke could be a predictor for total cost. Diringer et al. (9) used the National Institutes of Health Stroke Scale score (NIHSS) as a measurement for stroke severity and found that total hospital costs for patients with acute severe stroke (NIHSS score > 20) was more than twice that of patients with mild stroke. Yoneda et al. (8) also used HIHSS as a measurement of stroke severity. Total hospital costs were moderately correlated with the initial NIHSS. Because of the retrospective method, only limited GCS data for the measurement of stroke severity were available for the present study. For future studies, we aim to use more measurements, including a functional survey on admission to the acute ward, in a prospective manner.

After a thorough literature search, we found little evidence illustrating that fever can be associated with increasing total medical costs in stroke patients. One previous study (26) illustrated that in-hospital infection is a predictor of prolonged hospital stay in acute ischaemic stroke patients. Another study (27) illustrated that a history of pneumonia could predict higher hospital charge per day for patients admitted for inpatient rehabilitation. In our study, fever in the rehabilitation ward increased medical costs for acute stroke patients transferred to the rehabilitation ward. Fever is usually associated with certain infections, such as pneumonia or urinary tract infection, which also occur frequently in acute stroke patients. Antibiotic usage and/or delayed discharge due to infection treatment may thus increase medical costs. There are no references considering hypoalbuminaemia, hyponatraemia, or hypokalaemia as a predictor for total costs for stroke patients. However, hypoalbuminaemia has been associated with increased risks for medical complications in acute stroke patients (28) and stroke patients admitted to the rehabilitation ward (27, 29), although it has not been related to length of stay (27, 29). Post-stroke hyponatraemia (30) and hypokalaemia (31) are associated with poor outcomes (increased chance of death). We believe that hypoalbuminaemia, hyponatraemia, and hypokalaemia are somewhat related to certain medical complications, which might increase costs because of the need for management of complications.

No haemorrhagic stroke inpatients were enrolled in the present study from the beginning. Gioldasis et al. showed that the costs for patients with acute haemorrhagic strokes were significantly higher than those for patients with acute ischaemic strokes in a tertiary hospital (32) in Greece. Wei et al. (6) illustrated that acute intracerebral haemorrhage (ICH) was associated with a 19% greater cost than acute ischaemic stroke in a Level 2 hospital (a hospital with at least 100 inpatient beds providing acute medical care and preventative care services to populations of at least 100,000) in China. In the USA, the mean hospital cost for patients with ischaemic stroke was lower than that for patients with ICH and subarachnoid haemorrhage (33, 34). In Japan, patients with acute ICH had higher costs than those with acute ischaemic stroke (35). In Bottacchi's 3-year longitudinal study in Italy (36), the mean annual cost was significantly higher for patients with hemorrhagic stroke than for those with ischaemic stroke. In a study conducted in Taiwan, Tang et al. (10) included acute and chronic stroke patients (4 hospitals with different levels) admitted to the rehabilitation ward, providing evidence that haemorrhagic strokes had a higher total cost than ischaemic strokes. We considered that in the acute stage, more neurosurgical procedures and intensive care, greater disease severity, or longer length of hospital stay will be required for patients with haemorrhagic stroke than for those with ischaemic stroke.

To our knowledge, this is the first study analysing the predictors of total cost for first-ever ischaemic stroke patients

transferred to the rehabilitation ward and identifying that some complications or medical events as the predictors. However, the design of the study limited the extent of applications of the results, e.g. the data could not be applied to acute ischaemic stroke patients who received rehabilitation programmes but were not transferred to the rehabilitation ward, and to those who were readmitted to the rehabilitation ward for rehabilitation after discharge from the hospital following acute ischaemic stroke. The main limitations of the current study are that it is hospital-based only, and that we obtained only the total medical costs; no medical expense details were included in the analyses. Further studies should focus on analysing in more detail the costs of various factors using nationwide data for stroke patients who subsequently receive rehabilitation.

In conclusion, length of stay is a robust predictor for the total hospital cost for acute stroke patients transferred to the rehabilitation ward. Hypoalbuminaemia in the acute ward, fever, hypokalaemia, and hyponatraemia in the rehabilitation ward are identified as impact factors on the total hospital cost. These findings may be useful for clinicians to identify the risks of increasing total hospital costs in acute ischaemic stroke patients transferring to the rehabilitation ward. Furthermore, we hope that this information could help clinicians to understand that a lower occurrence of these identified complications might reduce the total medical costs.

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The authors declare no conflicts of interest.

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