Original Paper

Neuro
epidemiology

Neuroepidemiology 2009;32:142–149
DOI: 10.1159/000184747

Received: July 4, 2008
Accepted: August 29, 2008
Published online: December 17, 2008

Acute Treatment Costs of Stroke in Brazil

Michael C. Christensen[a] Raul Valiente[b] Gisele Sampaio Silva[c] Won Chan Lee[d] Sarah Dutcher[d] Maria Sheila Guimarães Rocha[b] Ayrton Massaro[c]

[a]Global Development, Novo Nordisk A/S, Bagsvaerd, Denmark; [b]Hospital Santa Marcelina, and [c]Federal University of São Paulo/Paulista School of Medicine, São Paulo, Brazil; [d]Abt Bio-Pharma Solutions Inc., Bethesda, Md., USA

Key Words

Intracerebral hemorrhage · Ischemic stroke · Hospital costs, Brazil

Abstract

Background and Purpose: Although stroke is the leading cause of death in Brazil, little information exist on the acute treatment provided for stroke and its associated costs. This study addresses this gap by both clinically and economically characterizing the acute treatment of first-ever intracerebral hemorrhage (ICH) and ischemic stroke (IS) in Brazil. ***Methods:*** Retrospective medical chart review using data from two high-volume stroke centers in São Paulo, Brazil. Clinical and resource utilization data for all patients admitted to the stroke centers with a first-ever stroke between January 1, 2006 and May 31, 2007 were collected and the mean acute treatment costs per person were calculated by assigning appropriate unit cost data to all resource use. Cost estimates in Brazilian reals (BRL) were converted to US dollars (USD) using the 2005 purchasing power parity index. National costs of acute treatment for incident strokes were estimated by extrapolation of mean cost estimate per person to national incidence data for the two types of stroke. The mean costs of acute treatment on a national scale were examined in sensitivity analysis. ***Results:*** A total of 316 stroke patients were identified and their demographic and clinical characteristics, patterns of care, and outcomes were examined. Mean length of hospital stay was 12.0 ± 8.8 days for ICH and 13.3 ± 23.4 days for IS. Ninety-one percent of the ICH patients and 68% of the IS patients were admitted to an intensive care unit (ICU). Mean total costs of initial hospitalization were USD 4,101 (SD ±4,254) for ICH and USD 1,902 (SD ±1,426) for IS. In multivariate analysis, hemorrhagic stroke, development of pneumonia, neurosurgical intervention, stay in ICU, and physical therapy were all significant independent predictors of acute treatment costs. Aggregate national health care expenditures for acute treatment of incident ICH were USD 122.4 million (range 30.8–274.2) and USD 326.9 million for IS (range 82.4–732.2). ***Conclusion:*** Acute treatment costs of incident ICH and IS in Brazil are substantial and primarily driven by the intensity of hospital treatment and in-hospital complications. With the expected increase in the incidence of stroke in Brazil over the coming decades, these results emphasize the need for effective preventive and acute medical care.

Copyright © 2008 S. Karger AG, Basel

Introduction

Stroke is the main cause of death in Brazil and presents the highest case fatality rate in Latin America [1, 2]. A recent study from the WHO reports an age-standardized death rate from stroke in Brazil to be roughly similar to that of China and Pakistan, and substantially higher than

M.C. Christensen is an employee of Novo Nordisk A/S. W.C. Lee and S. Dutcher have received consultancy fees for their assistance with this study. The institutions of R. Valiente, G. Sampaio Silva, M.S. Guimarães Rocha and A. Massaro have received a compensation for the time and effort involved in making data available for this study.

KARGER

Fax +41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

© 2008 S. Karger AG, Basel

0251–5350/09/0322–0142$26.00/0

Accessible online at:
www.karger.com/ned

Michael C. Christensen
Global Development, Novo Nordisk A/S
Krogshoejvej 55
DK–2880 Bagsvaerd (Denmark)
Tel. +45 4442 0557, Fax +45 4442 7390, E-Mail mcrc@novonordisk.com

observed in Europe and North America [3]. The latest evidence in Brazil indicates an annual stroke incidence rate of 108 per 100,000 individuals, and a 1-year case fatality rate of 31% [4]. Intracerebral hemorrhage (ICH), which is associated with a substantially worse prognosis than ischemic stroke (IS), accounts for approximately 14% of all strokes in the country [4].

Despite the significant consequences of stroke to the public health in Brazil, the cost of stroke has not been thoroughly evaluated. A number of studies have examined the incidence rate of stroke in specific geographic regions of Brazil, while others have considered incidence rates of specific stroke subtypes, as well as ethnic, socioeconomic, gender, and stroke type differences in mortality [5–10]. To our knowledge, no study has yet examined in detail the exact pattern of acute stroke treatment provided or the hospital costs associated with stroke treatment. Evidence of the actual treatment provided for stroke and its economic implications is, however, critical for judging the adequacy of current treatment practices, the potential for new therapeutic interventions, and hence optimal decision making in health care management and resource allocation. From a public health perspective, estimates of the acute treatment costs for patients with hemorrhagic stroke and IS are particularly important as they form the basis for understanding the future economic challenges presented by an increasing incidence and prevalence of the two major types of stroke.

To better understand the current treatment patterns for stroke and their costs in Brazil, this study considers both of these parameters in patients admitted to hospital for a first-ever stroke (ICH or IS).

Subjects and Methods

Patient Population

In the absence of a national stroke registry in Brazil that contains data on the annual number of hospital admissions for stroke, their treatment, or their treatment costs, we designed a retrospective study based on medical records at two Brazilian hospitals receiving a high volume of stroke patients. On the basis of the resource utilization observed at these hospitals, we assigned appropriate unit costs to estimate mean hospital costs per stroke patient, and on the basis of the published literature on the incidence of stroke in Brazil, we extrapolated mean treatment costs to a national level. We identified patients with a first-ever diagnosis of ICH or IS according to ICD-10 codes I60–I69, between January 1, 2006 and May 31, 2007, admitted to Hospital Santa Marcelina and Universidade Federal de São Paulo, São Paulo, Brazil. We included patients aged 21 years or older who were admitted for acute treatment with a confirmed diagnosis of ICH or IS through computed tomography (CT) scan or magnetic resonance imaging (MRI). To assess treatment patterns and costs in an *incident* stroke population, we excluded ICH and IS patients with a previous stroke. The institutional ethics committees at the two hospitals approved the study.

Data Collection

The following baseline data were collected from medical records: age, gender, recognized risk factors for stroke (i.e., arterial hypertension, alcohol intake, smoking, diabetes mellitus, dyslipidemia), and presence of comorbidities. In addition, baseline glucose level, systolic/diastolic blood pressure, body temperature, Glasgow Coma Scale (GCS) score, and CT scan findings were recorded. Radiological findings were determined in the initial CT scan and classified according to location and volume of hematoma, and midline shift (i.e., displacement of the septum pellucidum across midline). ICH volume was calculated by analysis of CT scans according to the ABC/2 method [11]. Data on neurological alterations (i.e., diplopia, right/left hemiparesis, headache, right/left hemiplegia, aphasia) at hospital admission were also recorded. All resource utilization data were collected regarding the treatment provided during initial hospitalization, including patient disposition status, length of stay [LOS; emergency room, intensive care unit (ICU), and general ward], diagnostic tests performed on admission and during the hospital stay (i.e., CT scan, MRI, echocardiography, digital angiography, carotid echo Doppler, chest X-ray), surgical interventions, intensive care procedures, radiology examinations, laboratory tests, and rehabilitation. Clinical outcomes were assessed as in-hospital mortality, functional outcome at hospital discharge, and discharge destination. Functional outcome was estimated on the basis of medical records and direct patient assessment, and reported according to the National Institutes of Health Stroke Scale (NIHSS) and/or the modified Rankin Scale (mRS). Discharge destination was recorded for each patient as either death or transfer to another hospital, nursing home, rehabilitation facility, the patient's home or other.

Statistical Analysis

Descriptive statistics on baseline characteristics, treatment provided, and outcomes observed were produced separately for ICH and IS. Continuous variables are described as mean ± SD or median values with 25th and 75th percentiles. To calculate costs of hospital care, we multiplied the specific resource use observed for each patient during their hospital stay with the appropriate national 2007 unit cost data obtained from Sistema Único de Saúde (SUS; United Health System) (see Appendix, online version only, www.karger.com/doi/10.1159/000184747 [12]. The costing methodology applied by SUS involves a surgical package if the patient undergoes surgery and a medical package for nonsurgical patients. The packages cover the costs of 7 general ward days, medication, laboratory tests, medical exams, and normal nutrition. All other health care services outside this package are reimbursement at service-specific rates. As the national unit cost data from SUS are not specific to stroke care, and the system applies tariffs that are well below actual costs, we applied a recommended adjustment factor of 3.125 (for medium-complexity procedures) to all unit costs to obtain a reasonable approximation to the actual costs incurred [13]. Cost estimates in Brazilian reals (BRL) were converted to US dollars (USD) using the 2005 purchasing power parity index (1 USD = 1.4 BRL) [14]. In the absence

Table 1. Patient characteristics on hospital admission

	ICH	IS
Patients	45	271
Age (mean ± SD), years	64 ± 13	61 ± 14
Male	27 (60)	145 (54)
Smoking	8 (18)	100 (37)
Alcoholism	8 (18)	41 (15)
Substance abuse	0 (0)	3 (1)
Comorbidity		
Diabetes mellitus	7 (16)	85 (31)
Arterial hypertension	38 (84)	216 (80)
Cardiovascular disease	4 (9)	41 (15)
Blood pressure (mean ± SD), mm Hg		
Systolic	170 ± 40	152 ± 40
Diastolic	100 ± 24	93 ± 28
Glucose level (mean ± SD), mg/dl	157 ± 69	149 ± 86
Hematoma volume, cm^3		
Mean ± SD	13 ± 14	NA
Median	9	NA
Minimum	0.4	
Maximum	75	
Midline shift present	11 (24)	10 (4)
Baseline NIHSS score		
Median	10	6
Minimum	1	1
Maximum	30	30
Baseline GCS score		
Median	14	15
Minimum	4	3
Maximum	15	15

Figures in parentheses indicate percentages.

of 2007 data, we assumed that the purchasing power parity had remained constant since 2005. To estimate the mean acute treatment costs for ICH and IS, we summed individual treatment costs divided by the respective number of patients. Acute treatment costs were stratified by patient characteristics to examine their statistical association. For continuous variables, we analyzed the relationship using ANOVA as well as a nonparametric Wilcoxon test, when the assumption of normality was untenable. For the analyses of categorical variables, the χ^2 test of association was conducted. We also investigated independent determinants of acute treatment costs in the combined cohort in multivariate analysis using ordinary least squares; $p < 0.05$ was considered statistically significant.

National Cost Estimation

The national costs of acute stroke treatment for incident strokes were estimated by multiplying the mean treatment costs with the estimated incidence rates of ICH and IS in Brazil (108 per 100,000 cases; 14.8% hemorrhagic and 85.2% ischemic) [4]. These incidence data are based on estimates provided by Minelli et al. [4] in the latest assessment of stroke incidence in the country. Population data were obtained from the United Nations Population and Vital Statistics Report and the Brazilian Institute for Geography and Statistics [15, 16]. We examined the sensitivity of our results by applying adjustment factors of 0.787 and 4.167 to the unit cost data provided by SUS. These recommended adjustment factors were based on the average ratio between SUS reimbursement rates and the actual costs of a high- and low-complexity procedure, respectively [13]. We also examined the sensitivity of the cost estimates using a much higher adjustment factor (7) with the concern that published adjustment factors severely underestimate the true cost of stroke care.

Results

Sample Characteristics

Baseline characteristics of the two patient groups are summarized in table 1. A total of 45 patients with a first-ever ICH and 271 with a first-ever IS were identified. The mean age was 64.0 years for ICH (SD ±13.3) and 61.3 years for IS (SD ±13.7). A higher proportion of IS patients were ≥70 years of age compared with ICH patients (39 vs. 29%). Males represented 60 and 54% of the ICH and IS populations, respectively. The most common comorbidities for both ICH and IS patients were hypertension, heart disease, and diabetes mellitus. A history of smoking and alcoholism was observed in 37 and 15% of IS patients, respectively, and in 18 and 18% of ICH patients, respectively.

Mean ICH volume on initial CT scan was 12.5 ± 13.7 ml (range 0.4–75.0). Median baseline GCS score upon hospital admission was 13.5 (range 4–15) for ICH and 15 (range 3–15) for IS. The median NIHSS score on admission was 10 (range 1–30) for ICH and 6 (range 1–30) for IS. Fourteen percent of the ICH patients had a GCS score ≤8 compared to 2% of the IS patients. The most significant neurological alterations for both types of stroke included right/left hemiparesis (47% for ICH and IS), and right/left hemiplegia (16% for ICH and 15% for IS). A total of 6% of the patients developed pneumonia during the hospitalization and 3% developed other infections. Overall in-hospital mortality was 33.3% for ICH and 6.6% for IS (table 2). At hospital discharge, the median NIHSS score was 6.0 (25th and 75th percentile: 4.5 and 12.5) for ICH patients and 4.0 (25th and 75th percentile: 2.0 and 6.0) for IS patients. Using the mRS as an outcome measure of disability, 38% of the ICH population and 79% of the IS population had no to moderate disability (mRS 0–3). A majority of patients in the ICH population (58%) and the IS population (91%) were discharged home.

Table 2. Clinical outcomes at hospital discharge

Clinical outcomes	ICH (n = 45)	IS (n = 271)
NIHSS score		
Patients	16	206
Mean ± SD	9 ± 7	5 ± 4
Median	6	4
25th percentile	5	2
75th percentile	13	6
≥15	3 (19)	5 (2)
<15	13 (81)	201 (98)
mRS scale score		
Patients	39	255
0	0 (0)	15 (6)
1	6 (15)	60 (24)
2	4 (10)	88 (35)
3	5 (13)	38 (15)
4	8 (21)	33 (13)
5	1 (3)	3 (1)
6	15 (39)	18 (7)
Discharge referral status		
Dead	15 (33.3)	18 (6.6)
Other acute hospital	3 (6.7)	4 (1.5)
Nursing home[1]	0 (0)	0 (0)
Rehabilitation facility	1 (2.2)	1 (0.4)
Home	26 (57.8)	246 (90.8)
With ambulatory control[2]	8 (17.8)	48 (17.7)
Other	0 (0)	2 (0.7)

Figures are numbers with percentages in parentheses, unless indicated otherwise.
[1] The Brazilian public health care system does not offer nursing homes as a treatment facility.
[2] Patients discharged home, yet required to return to hospital for regular checkups.

Table 3. Treatment patterns for ICH and IS

	ICH	IS
Days in hospital		
ICU		
Patients admitted, %	27	6
Mean stay (± SD)	2.7 ± 5.6	0.3 ± 1.7
Stroke unit[1]		
Patients admitted (overall), %	7	11
Mean stay (± SD)	0.3 ± 1.3	1.3 ± 4.7
Patients admitted at UNIFESP, %	50	47
General ward		
Patients admitted, %	69	82
Mean stay (± SD)	6.6 ± 7.1	7.9 ± 6.6
Total length of stay (mean ± SD)	12.0 ± 8.8	13.3 ± 23.4
Imaging exams – baseline (>24 h)[2]		
CT scan	35 (78)	226 (83)
Echocardiography	0 (0)	4 (2)
Carotid echo Doppler	0 (0)	10 (4)
Chest X-ray	4 (9)	48 (18)
Follow-up exams (>24 h)[2]		
CT scan	32 (71)	84 (31)
MRI	5 (11)	95 (35)
Echocardiography	0 (0)	47 (17)
Digital angiography	6 (13)	71 (26)
Carotid echo Doppler	1 (2)	105 (39)
Surgical procedures[2]		
Hematoma evacuation	6 (13)	3 (1)
Ventricular peritoneal shunt	4 (9)	0 (0)
Intracranial pressure monitoring	1 (2)	0 (0)
Intensive care[2]		
Nasogastric intubation	23 (51)	48 (18)
Mechanical ventilation	13 (29)	11 (4)
Laboratory tests[2]		
Glycemia/glucose	34 (76)	185 (68)
Platelets	39 (87)	256 (95)
Prothrombin time	31 (69)	184 (68)
Activated partial thromboplastin time	34 (76)	197 (73)
Liver function	3 (7)	34 (13)
Renal function	20 (44)	78 (29)

UNIFESP = Universidade Federal de São Paulo.
[1] Only UNIFESP contains a stroke unit.
[2] Figures indicate numbers with percentages in parentheses.

Treatment Patterns

The overall mean hospital LOS was 12.0 ± 8.8 days for ICH and 13.3 ± 23.4 days for IS (table 3). Twenty-seven percent of ICH patients and 6% of IS patients were admitted to an ICU for a mean LOS of 2.7 ± 5.6 and 0.3 ± 1.7 days, respectively. Overall, 78% of ICH patients and 83% of IS patients had a CT scan upon hospital admission (i.e., within 24 h). During follow-up (i.e., after the first 24 h following admission), a significant proportion of IS patients underwent a digital angiography (26%), MRI (35%), and carotid echo Doppler (39%). Among ICH patients, 13% underwent surgical evacuation for their hematoma, 9% had a ventricular peritoneal shunt, and only 2% underwent intracranial pressure monitoring. In addition, 29% of ICH patients were mechanically ventilated during intensive care. Twenty-seven percent of ICH patients and 16% of IS patients were seen by a physical therapist, while 22 and 17%, respectively, were seen by a nutritionist.

Costs

Mean cost of initial hospital care was USD 4,101 (SD ±4,254) per ICH patient, and USD 1,902 (SD ±1,426) per IS patient (table 4). Given the unit costing methodology applied by SUS, the surgical and medical packages com-

Table 4. Mean cost per patient (in USD)[1] in 2007 (with sensitivity analysis)

Medical resource	Unadjusted (SUS reimbursement rates)		Conversion for high-complexity procedures (0.787)[2]		Conversion for medium-complexity procedures (3.125)[2]	
	ICH (n = 45)	IS (n = 271)	ICH	IS	ICH	IS
Surgical package[3]	311 ± 628	29 ± 178	244 ± 494	23 ± 140	970 ± 1,963	90 ± 556
Medical package[4]	223 ± 113	264 ± 62	175 ± 89	208 ± 49	696 ± 352	825 ± 193
Room and board						
Emergency room[5]	0 ± 0	0.1 ± 0.9	0 ± 0	0.11 ± 0.7	0 ± 0	0.4 ± 3
ICU	407 ± 851	48 ± 265	320 ± 669	38 ± 208	1,272 ± 2,658	151 ± 828
General ward[6]	3 ± 5	5 ± 5	3 ± 4	4 ± 4	11 ± 14	15 ± 15
Imaging and radiology exams						
CT scan	245 ± 141	152 ± 83	193 ± 111	120 ± 65	766 ± 441	476 ± 258
MRI	2 ± 7	8 ± 11	2 ± 5	6 ± 9	7 ± 20	25 ± 35
Echocardiography	0 ± 0	16 ± 36	0 ± 0	12 ± 28	0 ± 0	49 ± 112
Digital angiography	17 ± 44	34 ± 56	13 ± 35	26 ± 44	53 ± 137	105 ± 176
Carotid echo Doppler	0.5 ± 3	10 ± 12	0.4 ± 3	8 ± 9	2 ± 10	30 ± 38
Transcranial Doppler	0 ± 0	5 ± 19	0 ± 0	4 ± 15	0 ± 0	15 ± 61
Doppler of the lower extremities	0 ± 0	1 ± 11	0 ± 0	1 ± 9	0 ± 0	3 ± 34
Support						
Nasogastric intubation	91 ± 148	35 ± 107	71 ± 116	28 ± 84	284 ± 461	108 ± 333
Parenteral nutrition	0 ± 0	1 ± 13	0 ± 0	1 ± 10	0 ± 0	2 ± 41
Central venous catheter	13 ± 30	2 ± 14	10 ± 24	2 ± 11	40 ± 94	8 ± 44
Total cost						
Mean ± SD	1,312 ± 1,361	609 ± 457	1,033 ± 1,071	480 ± 359	4,101 ± 4,254	1,902 ± 1,426
Median	586	526	461	414	1,831	1,645
25th percentile	526	424	414	334	1,645	1,326
75th percentile	1,851	582	1,456	458	5,783	1,820

[1] Costs were converted to USD using the 2005 purchasing power parity index (1.4 BRL = 1 USD). Since there are no 2007 purchasing power parity data available, we assume that the 2005 rate has remained constant.
[2] Cost adjustment factors are based on the average ratio between SUS reimbursement rates and actual costs of given procedures, grouped by level of complexity.
[3] Surgical package cost is used for all patients who underwent any surgical procedure.
[4] Medical package cost is used for all patients who did not undergo any surgical procedure, and had an emergency room LOS >48 h or who were transferred from the emergency room to another hospital setting during their hospitalization.

bined represented the largest proportion of costs (41% for ICH and 48% for IS). Other major cost components were stay in the ICU (31% of total costs for ICH and 8% for IS) and CT scanning (19% of costs for ICH and 25% for IS). The mean treatment cost differed significantly by NIHSS score upon hospital admission for IS (NIHSS score ≥15: USD 2,397; NIHSS <15: USD 1,811; p = 0.006), while a strong trend towards higher costs was observed for ICH (NIHSS score ≥15: USD 5,663; NIHSS <15: USD 3,117, p = 0.086). The treatment costs for ICH patients who underwent neurosurgery were almost four times higher than for patients who did not undergo surgery (USD 10,256 vs. USD 2,562, p < 0.001). ICH patients who developed pneumonia during the hospital stay also incurred significantly higher costs (USD 8,485 vs. USD 3,553, p = 0.015), as did IS patients with pneumonia (USD 4,251 vs. USD 1,776, p < 0.001) and other infections (USD 3,435 vs. USD 1,857, p = 0.007). Finally, costs also differed significantly by mRS score at discharge for both ICH (p = 0.032) and IS (p = 0.007) patients. In ICH patients, the mean cost by mRS ranking ranged from USD 1,475 (mRS score = 1) to USD 6,370 (mRS score = 4), while the mean costs for IS patients ranged from USD 1,622 (mRS score = 0) to USD 3,188 (mRS score = 4). When adjusting for all patient and treatment characteristics in multivariate analysis, stroke type (USD 708), development of pneumonia (USD 1,456),

Conversion for low-complexity procedures (4.167)[2]		High conversion factor (7.0)	
ICH	IS	ICH	IS
1,294 ± 2,617	121 ± 742	2,174 ± 4,397	202 ± 1,246
928 ± 469	1,101 ± 257	1,560 ± 789	1,849 ± 432
0 ± 0	1 ± 4	0 ± 0	1 ± 6
1,696 ± 3,544	202 ± 1,104	2,849 ± 5,954	339 ± 1,854
14 ± 19	19 ± 20	24 ± 32	33 ± 33
1,021 ± 588	635 ± 344	1,716 ± 987	1,066 ± 578
10 ± 27	33 ± 47	16 ± 46	56 ± 79
0 ± 0	65 ± 150	0 ± 0	109 ± 251
71 ± 183	140 ± 235	119 ± 308	234 ± 394
2 ± 14	41 ± 50	3 ± 23	68 ± 84
0 ± 0	20 ± 81	0 ± 0	33 ± 136
0 ± 0	4 ± 46	0 ± 0	7 ± 77
378 ± 615	144 ± 445	636 ± 1,033	241 ± 747
0 ± 0	3 ± 54	0 ± 0	6 ± 91
53 ± 125	10 ± 58	89 ± 211	17 ± 98
5,468 ± 5,672	2,536 ± 1,902	9,186 ± 9,529	4,260 ± 3,195
2,441	2,193	4,101	3,684
2,193	1,768	3,684	2,971
7,711	2,426	12,954	4,076

[5] Patient is charged emergency room cost only if emergency room LOS <48 h and the patient was not transferred to another setting (i.e. discharged from or died in emergency room).
[6] General ward cost is charged to patients for every additional day after a 7-day LOS in the general ward.

neurosurgical intervention (USD 3,225), stay in ICU (USD 3,654), and physical therapy (USD 373) were significant independent predictors of acute treatment costs (table 5). The predictive model explained a very large proportion of the variation in treatment costs ($R^2 = 0.79$).

Extrapolating the mean costs of initial hospital care for first-ever ICH and IS to the overall incidence of these forms of stroke in Brazil (16 per 100,000 for ICH and 92 per 100,000 for IS) resulted in aggregate national health care expenditures of USD 122 million for ICH and USD 327 million for IS. Exploring the sensitivity of these results to the unit cost data applied in the baseline estimation by applying a factor of 0.787–7.0 to the unadjusted data provided by SUS implied a range of mean initial hospital costs of USD 1,312–9,186 per ICH patient, and USD 609–4,260 per IS patient. At a national level, these sensitivity analyses implied health care expenditures of USD 39 million to USD 274 million for ICH and USD 105 million to USD 732 million for IS.

Table 5. Multivariate analysis of hospital treatment costs for stroke

Variable	Coefficient	p value
Stroke subtype (reference: IS)		
ICH	708.02	<0.0001
Age	–4.25	0.327
Gender (reference: female)		
Male	–77.05	0.479
Died during hospitalization	–262.81	0.221
GCS score on admission [reference: mild (13–15)]		
Moderate/severe (3–12)	123.60	0.515
Development of pneumonia	1,456.21	<0.001
Development of infection	–182.74	0.629
Hypertension	–175.70	0.223
Diabetes	18.17	0.884
Dyslipidemia	3.26	0.987
Heart disease	30.00	0.890
Cardiac arrhythmia	228.88	0.335
Chronic renal insufficiency	273.32	0.293
Underwent neurosurgery	3,224.56	<0.001
Stay in ICU	3,653.70	<0.001
Physical therapy	372.62	0.014
R^2	0.786	

Discussion

This study provides the first detailed description of the acute treatment costs associated with stroke in Brazil. We find mean acute treatment costs per ICH patient of USD 4,101 and USD 1,902 per IS patient. At a national level, the annual cost of acute stroke treatment translates into USD 122 million for ICH and USD 327 million for IS. It is important to note, however, that the cost of acute care for stroke only represents the 'tip of the iceberg' from a societal level. In addition to the direct costs associated with follow-up care and home care after hospital discharge, there are also indirect costs associated with stroke in terms of foregone productive activity attributable to premature mortality and morbidity. Economic studies on the cost of stroke in Europe and the United States indicate that as much as 65% of the total lifetime

societal cost associated with stroke may relate to indirect costs [17, 18].

Our study is the first of its kind to document the costs of hospital care for incident stroke in Brazil. As evident from the WHO Global Infobase, there is a pronounced scarcity of epidemiological studies of stroke in developing countries – ranging from 'simple' monitoring of the incidence of the disease, to the more elaborate evaluation of risk factors, clinical outcomes and even health economic evaluations [19]. This finding is particularly disturbing as approximately two thirds of all strokes occur in precisely these countries [20–22]. The WHO STEPS Stroke Surveillance System has been initiated to assist health care planners and policy makers in ongoing systematic data collection, analysis and dissemination of stroke data. Reliable data are clearly a prerequisite for developing cost-effective strategies for meeting the demands for stroke prevention and health care [19]. However, detailed evidence of the actual treatment provided for stroke and its economic implications is also critical in developing countries. Such information allows health care planners at a local and national level to judge the adequacy of current treatment practices, and prioritize health care resources between prevention and treatment, as well as within the health care system from emergency medicine to follow-up care and rehabilitation.

In our study, we find the acute treatment cost of stroke driven by neurosurgical interventions, stay in ICU, physical rehabilitation, and development of pneumonia. While the value of neurosurgical interventions after ICH has recently been debated [23], it is clear that both stay in ICU and physical rehabilitation represent core components of modern stroke care [24–26]. Development of pneumonia on the other hand is a very tangible clinical complication, which may effectively be addressed. Careful monitoring of fever after stroke is necessary to help rapid detection and treatment of pneumonia. Development of pneumonia may also potentially be prevented through careful protection of the airway and suctioning to lower the risk of aspiration. Measures to treat nausea and vomiting may also lower the risk of aspiration pneumonia [25]. While a greater focus on infection control and management may increase the costs over the short term, the long-term societal benefits from improved clinical outcomes may be substantial due to a lower level of forgone productive activity.

The initial hospitalization costs for ICH and IS observed in our study are substantially lower than cost estimates reported for European countries and the USA. In Germany, Weimar et al. [27], for instance, examined outcomes and cost of stroke care across 30 German centers between 1998 and 1999, and reported mean treatment costs of EUR 4,679 (USD 6,945) for 4,510 patients admitted with IS and EUR 5,301 (USD 7,865) for 578 patients admitted with ICH. Quite similarly, Dodel et al. [28] reported mean treatment costs of EUR 3,480 (USD 5,167) for 179 patients admitted with IS and EUR 5,080 (USD 7,543) for 33 patients admitted with ICH. In the USA, the mean costs of the initial hospitalization for IS and ICH have recently been estimated at USD 6,190 and USD 10,552, respectively, in the Medicare population [29]. Although international differences in inpatient resource utilization and follow-up care can be attributed to differences in clinical practices and guidelines, the organization and financing of health care also play an important role. The reimbursement rates offered by SUS in Brazil, for instance, are substantially lower than observed in the United States and Europe.

This study has some limitations. First, we were limited by the data available in Brazil for this study. As no national or regional electronic database or registry exists on the annual number of stroke patients treated in hospital, their exact form of treatment, or their costs, it was necessary to study these parameters retrospectively through a review of medical records at selected hospitals with a high volume of stroke patients. As a result it remains an open question whether and to what extent our observations on treatment patterns and costs can be generalized to all hospital centers in Brazil. In our sensitivity analysis, however, we examined a very broad range of assumptions on the cost of stroke care, and the cost of stroke at other hospital centers in Brazil needs to be dramatically different to result in national cost estimates substantially different from our results. Nevertheless, as part of future research, it is recommended that a prospective, country-wide, observational study or national registry is initiated to confirm our findings. Second, in Brazil the use of health care services also differs greatly according to socioeconomic status. The population with higher income frequently uses private health care services at different quality, quantity, and price than observed at public institutions. As our study focused only on the cost of acute and subacute stroke care provided at public hospitals, the overall cost of stroke care in Brazil will clearly be higher than reported in this study if also private health care spending had been included. Third, we were also limited by available unit cost data in Brazil. The reimbursement rates provided by SUS are widely recognized as poor estimates of the true costs of health care. While we made a conservative correction in our estimations to account for the fact that the SUS unit cost data cannot be considered representative of the true cost of stroke care in Brazil, future research should aim to

collect nationally representative unit cost data. Fourth, our study only addressed the direct initial hospital costs of stroke. Excluding the cost of all nonhospital health care implies an underestimation of the full economic cost of ICH and IS to health care payers. Lastly, our study did not take into account the impact of ICH and IS on quality of life. Given that many ICH and IS survivors are left with significant functional disabilities, the nonmonetary cost to survivors and their family can be substantial.

In summary, we find the mean initial hospitalization costs for ICH and IS in Brazil to be substantial, and primarily driven by intensity of hospital treatment and in-hospital complications. With the expected increase in the incidence of stroke in Brazil over the coming decades, these results emphasize the need for effective preventive and acute medical care.

Acknowledgements

This study was funded by Novo Nordisk A/S. The authors would like to thank Yu-Chen Yeh and Qin Wang at Abt Bio-Pharma Solutions Inc. for their help in analyzing the data and Ricardo Bitran and Juanita Ubilla, Bitrán & Asociados, for their help in collecting the data for this study.

References

1 Rodríguez T, Malvezzi M, Chatenoud L, Bosetti C, Levi F, Negri E, La Vecchia C: Trends in mortality from coronary heart and cerebrovascular diseases in the Americas: 1997–2000. Heart 2006;92:453–460.
2 Lotufo PA: Stroke in Brazil: a neglected disease. Sao Paulo Med J 2005;123:3–4.
3 Strong K, Mathers C, Bonita R: Preventing stroke: saving lives around the world. Lancet Neurol 2007;6:182–187.
4 Minelli C, Fen LF, Menelli DPC: Stroke incidence, prognosis, 30-day, and 1-year case fatality rates in Matão, Brazil. A population-based prospective study. Stroke 2007:38: 2906–2911.
5 Cabral NL, Longo AL, Moro CH, Amaral CH, Kiss HC: Epidemiologia dos accidentes cerebrovasculares em Joinville, Brazil. Estudo institutional. Arq Neuropsiquatr 1997;55: 357–363.
6 Siqueira Neto JL, Santos AC, Fabio SR, Sakamoto AC: Cerebral infarction in patients aged 15 to 40 years. Stroke 1996;27:2016–2019.
7 Zétola VH, Nóvak EM, Camargo CH: Stroke in young adults: analysis of 164 patients. Arq Neuropsiquiatr 2001;59:740–745.
8 Lutufo PA, Goulart AC, Bensenor IM: Race, gender, and stroke subtypes mortality in São Paulo, Brazil. Arq Neuropsiquiatr 2007;65: 752–757.
9 Massaro AR: Stroke in Brazil: a South America perspective. Int J Stroke 2006;1:113–115.
10 Martins ANN, de Figueiredo MM, Rocha OD, Fernandes MAF, Jeronimo SMB, Dourado ME: Frequency of stroke types at an emergency hospital in Natal, Brazil. Arq Neuropsiquiatr 2007;65:1139–1143.
11 Kothari RU, Brott T, Broderick JP, Barsan WG, Sauerbeck LR, Zuccarello M, Khoury J: The ABCs of measuring intracerebral hemorrhage volumes. Stroke 1996;27:1304–1305.
12 Sistema Único de Saúde (Brazil's Unified Health System). http://w3.datasus.gov.br/datasus/datasus.php.
13 De Matos V: RFP n° 003/99 Projeto REFORSUS e CNPQ – Apuracao dos custos de Procedimentos hospitalares: Alta e média complexidade, 2002.
14 World Bank: 2005 international comparison program. 2005. http://siteresources.worldbank.org/ICPINT/Resources/summary-tables.pdf.
15 United Nation Statistics Division: Population and vital statistics report (mid-year 2005–2006 estimate). http://unstats.un.org/unsd/demographic/products/vitstats/serATab2.pdf.
16 Brazilian Institute for Geography and Statistics (IBGE): Estimativas para 1 de Julho de 2006. 2006. http://www.ibge.gov.br/home/estatistica/populacao/estimativa2006/estimativa.shtm.
17 Navarrete-Navarro P, Hart WM, Lopez-Bastida J, Christensen MC: The societal costs of intracerebral hemorrhage in Spain. Eur J Neurol 2007;14:556–562.
18 Taylor TN, Davis PH, Torner JC, Holmes J, Meyer JW, Jacobson MF: Lifetime cost of stroke in the United States. Stroke 1996;27: 1459–1466.
19 Bonita R, Mendis S, Truelsen T, Bogousslavsky J, Toole J, Yatsu F: The global stroke initiative. Lancet Neurol 2004;3:391–393.
20 World Health Organization: The World Health Report 2003: Shaping the Future. Geneva, World Health Organization, 2003.
21 Danesi M, Okubadejo N, Ojini F: Prevalence of stroke in an urban, mixed-income community in Lagos, Nigeria. Neuroepidemiology 2007;28:216–223.
22 Del Brutto OH, Idrovo L, Santibáñez R, Díaz-Calderón E, Mosquera A, Cuesta F, Navas C: Door-to-door survey of major neurological diseases in rural Ecuador – The Atahualpa Project: methodological aspects. Neuroepidemiology 2004;23:310–316.
23 Mendelow AD, Gregson BA, Fernandes HM, Murray GD, Teasdale GM, Hope DT, Karimi A, Shaw MDM, Barer DH: Early surgery versus initial conservative treatment in patients with spontaneous supratentorial intracerebral hematomas in the international surgical trial in intracerebral hemorrhage (STICH): a randomised trial. Lancet 2005;365:387–397.
24 European Stroke Initiative Executive Committee, EUSI Writing Committee, Olsen TS, Langhorne P, Diener HC, Hennerici M, Ferro J, Sivenius J, Wahlgren NG, Bath P: European stroke initiative recommendations for stroke management – Update 2003. Cerebrovasc Dis 2003;16:311–337.
25 Adams HP, del Zoppo G, Alberts MJ, Bhatt DL, Brass L, Furlan A, Grubb RL, Higashida RT, Jauch EC, Kidwell C, Lyden PD, Morgenstern LB, Qureshi AI, Rosenwasser RH, Scott PA, Wijdicks EF: Guidelines for the early management of adults with ischemic stroke. Stroke 2007;38:1655–1711.
26 Feys H, De Weerdt W, Verbeke G, Steck GC, Capiau C, Kiekens C, Dejaeger E, Van Hoydonck G, Vermeersch G, Cras P: Early and repetitive stimulation of the arm can substantially improve the long-term outcome after stroke: a 5-year follow-up study of a randomized trial. Stroke 2004;35:924–929.
27 Weimar C, Weber C, Wagner M, et al: Management patterns and health care use after intracerebral hemorrhage: a cost-of-illness study from a societal perspective in Germany. Cerebrovasc Dis 2003;15:29–36.
28 Dodel RC, Haacke C, Zamzow K, Paweilik S, Spottke A, Rethfeldt M, Siebert U, Oertel WH, Schoffski O, Back T: Resource utilization and costs of stroke unit care in Germany. Value Health 2004;7:144–152.
29 Lee WC, Christensen MC, Joshi A, Pashos CL: Long-term cost of stroke subtypes among Medicare Beneficiaries. Cerebrovasc Dis 2007;23:57–65.