Costs and Rehabilitation Use of Stroke Survivors: A Retrospective Study of Medicare Beneficiaries

Richard D. Zorowitz, Er Chen, Kuo Bianchini Tong, and Marianne Laouri

Objective: To examine mortality, costs, and rehabilitation use in patients with stroke and stroke-related hemiparesis during a 4-year period following stroke onset. **Method:** This study was a retrospective, longitudinal claims analysis. Patients newly diagnosed with stroke and discharged from the hospital were identified from a 5% random sample of Medicare beneficiaries. Mortality, total Medicare costs, use of rehabilitation, and associated costs in stroke survivors with or without hemiparesis were the main outcome measures. **Results:** Out of 4,604 newly diagnosed stroke patients, 1,166 developed hemiparesis. The 4-year mortality rate was significantly higher in the hemiparesis cohort than the nonhemiparesis cohort (55.2% vs. 47.5%; $p < .01$). The average Medicare cost per patient over the 4-year period was $77,143 for the hemiparesis cohort and $53,319 for the nonhemiparesis cohort ($p < .01$). A significantly higher proportion of patients in the hemiparesis cohort received rehabilitation than in the nonhemiparesis cohort (84% vs. 36% in Year 1, 30% vs. 10% in Year 2, 21% vs. 9% in Year 3, 16% vs. 7% in Year 4). Among patients who received rehabilitation, costs were significantly higher for the hemiparesis cohort ($17,680) than for the nonhemiparesis cohort ($7,841) in the first year. While most rehabilitation costs for the hemiparesis cohort were incurred in the hospital inpatient setting in the first year, the cost burden shifted to skilled nursing facilities and home health agencies in the following 3 years. **Conclusions:** Hemiparesis following stroke onset contributes to a higher mortality rate and higher Medicare costs in both the short and long term. **Key words:** *cost, hemiparesis, rehabilitation, stroke*

Stroke is the third leading cause of death and a leading cause of adult disability, affecting some 795,000 people each year in the United States.[1] Of stroke survivors, 30% are unable to walk without some assistance, and 26% are dependent in activities of daily living. Approximately 15% to 30% are left permanently disabled, and 20% require institutional care at 3 months after onset.[2] Long-term disability from stroke not only affects functional status but also has profound emotional and social effects on stroke survivors.[3]

Hemiparesis, a detrimental side effect that many stroke victims face, is the partial paralysis of one side of the body that occurs due to brain injury. The sudden onset of hemiparesis is a common early sign of stroke.[4] It is remarkably prevalent: acute cases of hemiparesis are present in nearly 80% of stroke victims; chronic cases occur in about 40% of patients.[5] Six months after a stroke, 50% of stroke survivors experience residual hemiparesis.[1]

Hemiparesis has a large impact on motor function. Patients with hemiparesis experience skeletal muscle atrophy and have more fat in the muscle on the affected side of their body, which may carry a greater risk of causing disability and cardiovascular disease.[6] Moreover, hemiparesis can also impair spatial sense and information processing, depending on which side of the brain the stroke occurred.[5] Moderate to severe hemiparesis, therefore, can be considered a prognostic factor for

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disability, institutionalization, and death 5 years post stroke.[7] Management of hemiparesis often includes physical and occupational therapy as well as an array of different techniques that further contribute to the high cost of stroke.[8]

It is estimated that the combined direct and indirect costs of stroke were $68.9 billion in the United States in 2009.[1] In 2006, $3.9 billion ($7,449 per discharge) was paid for Medicare beneficiaries discharged from short-stay hospitals for stroke.[1] The average cost of stroke per patient ranges from $27,000 to $475,000, depending on the age of a patient at stroke onset.[9] The mean lifetime cost of ischemic stroke in the United States, including inpatient care, rehabilitation, and follow-up care necessary for residual deficits, was estimated to be $140,048.[10]

Although studies have shown that timely, intensive, and organized rehabilitation improves patients' physical function and quality of life after an acute stroke,[11–13] population-based estimates of prevalence and costs of rehabilitation use among the elderly population are lacking. Furthermore, there are no long-term studies that disaggregate patients with hemiparesis following stroke from the overall stroke population. In an attempt to better understand the long-term treatment patterns and associated costs of stroke and hemiparesis, this study examined mortality, overall costs, and rehabilitation-related costs of stroke survivors with and without hemiparesis in the 4 years following stroke onset in US Medicare beneficiaries.

Materials and Methods

Data source

This retrospective, longitudinal study used the Medicare Standard Analytic Files (SAFs) from 2003 to 2006. SAFs contain information collected by the Centers for Medicare and Medicaid Services (CMS) regarding payment for health care services provided to Medicare beneficiaries. SAFs include beneficiary-level claims for a 5% randomly selected sample of Medicare beneficiaries (i.e., individuals aged 65 years or older, those eligible for disability, and/or end-stage renal disease patients). Medicare SAFs have been widely used by researchers studying outcomes, clinical epidemiology, and health services utilizations among elderly patients in the United States. Included in the SAFs are beneficiaries' demographic and clinical characteristics, medical care services provided across different care settings, and the charges and payments for each service rendered in hospital inpatient, outpatient, skilled nursing facility (SNF), home health agency (HHA), and hospice settings as well as physician services and durable medical equipment (DME). Each claim included in the SAFs includes total charge (i.e., the amount charged by a provider or a physician for a service or supply), Medicare allowable charge (the amount Medicare determines to be reasonable payment to a provider or physician, which includes the coinsurance and deductibles), and Medicare claim payment (i.e., the amount paid to a provider or physician by Medicare excluding the coinsurance and deductibles). As this study attempted to understand the cost of stroke incurred by the Medicare program, Medicare claim payment was used as the cost of care rather than total charge or Medicare allowable charge. A separate denominator file that is linked to the claims files includes demographic characteristics (age, gender, race, etc.) and, for patients who died, dates of death. We linked the beneficiaries' data from different claims databases via encrypted beneficiary identification numbers at each individual level and followed them longitudinally from January 2003 to December 2006.

Identification of study population

The patient population of interest in this study was patients who were hospitalized and subsequently discharged from the hospital with a newly diagnosed stroke in the first quarter of 2003. Patients were selected based on the presence of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes (430, 431, 434.00, 434.01, 434.10, 434.11, 434.90, 434.91, 435.0, 435.1, 435.3, 435.8, 435.9, 436) in a hospital inpatient claim. Patients were excluded if they met one of the following criteria: deceased during the hospitalization; not enrolled in the Medicare Part A/Part B in 2002; had at least two physician claims with stroke-related diagnosis or claims suggesting they received rehabilitation in 2002; or lack of continuous Medicare enrollment to the time of death or 2006, whichever came first.

For the identified patients, claims were extracted and linked from all settings of care from 2003 to 2006. Patients were stratified by the presence of hemiparesis (ICD-9-CM code 438.2) as a primary or secondary diagnosis on any claim in 2003 to obtain two study cohorts: (1) stroke patients who subsequently developed hemiparesis (hemiparesis cohort), and (2) stroke patients who did not develop hemiparesis (nonhemiparesis cohort).

Baseline characteristics

Patients' demographic characteristics, including age, gender, and race, were analyzed. In addition, comorbidities of these patients were assessed using the Charlson Comorbidity Index (CCI), which was designed as a measure of the risk of 1-year mortality attributable to various comorbidities.[14] Disease categories assessed in the CCI include, but are not limited to, myocardial infarction, congestive heart failure, diabetes, chronic obstructive pulmonary disease (COPD), peripheral vascular disease, moderate-to-severe renal disease, and any type of tumor, with a higher score indicating a greater level of comorbidity. CCI has been independently validated in stroke patients for predicting long-term functional outcomes.[15,16] In this study, patients' comorbidities were identified by ICD-9-CM diagnosis codes on claims submitted in 2002 based on the Deyo adaptation of the CCI using ICD-9-CM administrative databases.[17]

Study outcomes

Death was identified from the SAF denominator files from 2003 to 2006. Total number of deaths and time of death were compared between the hemiparesis cohort and nonhemiparesis cohort. Time from the initial stroke hospitalization to death was examined using a Kaplan-Meier survival curve for both cohorts.

Average Medicare cost per patient was calculated from 2003 to 2006. Medicare costs in each setting of care were categorized and compared between the two cohorts. Due to the complexity involved in ascribing cost to stroke or other conditions, this study did not attempt to distinguish stroke-related cost from non-stroke-related cost. Patients' co-pay and co-insurance amounts were excluded from this analysis. Cumulative costs during the follow-up period were analyzed using the Kaplan-Meier Sampling Average Estimates (KMSA). Costs associated with prescription drugs were not considered because Medicare did not cover prescription drugs during the study period. Also, since Medicare did not cover long-term SNF care (i.e., Medicare covers SNFs up to 100 days), costs encountered beyond 100 days in an SNF were not included. All costs were reported in US dollars in each calendar year.

Rehabilitation use

Medicare claims were assessed for stroke-related rehabilitation provided across different care settings: long-term acute care (LTAC), inpatient rehabilitation facility (IRF), SNF, HHA, and outpatient facility. Rehabilitation included physical, occupational, speech and language treatments and evaluations, as well as other care involving use of physical medicine and rehabilitation procedures. In LTAC and IRFs, patients with Diagnosis-Related Group (DRG) 462 or ICD-9-CM V57 in any claims were considered receiving inpatient rehabilitation. Rehabilitation use was identified via Current Procedural Terminology (CPT) and Healthcare Common Procedure Coding System (HCPCS) codes in the outpatient setting and physician services. SNFs and HHAs usually provide extensive services and rehabilitation to patients after they are discharged from the hospital. These services were identified via resource use group (RUG) in SNFs and HCPCS in HHAs. To associate rehabilitation use with initial stroke onset, the claims had to be accompanied by a cerebrovascular disease diagnosis code (ICD-9-CM 430-438) to be deemed a stroke-related rehabilitation claim. Detailed descriptions of codes used to identify rehabilitation are presented in the **Appendix**.

Medicare payments for the entire claim identified above were assumed to be associated with rehabilitation services. When calculating average Medicare cost for rehabilitation, only patients receiving rehabilitation in each year were included in the denominator in that year. Total Medicare rehabilitation costs were calculated by aggregating costs incurred by each patient in the hemiparesis and nonhemiparesis cohorts from 2003 to 2006.

Statistical analyses

Descriptive statistical analyses were carried out for patients' demographics, comorbidities, mortality, and rehabilitation use, as well as the Medicare costs in each care setting. All continuous variables were expressed as mean, median, and standard deviation. Student's *t* tests were performed on all continuous variables, except for Medicare costs which were analyzed via nonparametric Wilcoxon rank-sum test due to non-normal distribution of cost data. Chi-square tests were used for all categorical variables.

Time from the initial stroke hospitalization to death was examined using Kaplan-Meier survival curves. The KMSA approach was used to estimate the cumulative Medicare costs. Average cost and the Kaplan-Meier survival estimate for each follow-up quarter were obtained. The KMSA estimator for the cumulative Medicare costs was the sum of the product of these two components for the study sample. In other words, the survival estimates were used as a weighting function for the cost data.

Level of significance (alpha) for all statistical tests was set at 0.05. All analyses were conducted using SAS software version 9.1 (SAS Institute, Inc., Cary, NC).

Results

Study cohort and baseline characteristics

This study identified 6,872 patients who were hospitalized for stroke in the first quarter of 2003. Of these patients, 713 (10.4%) died in the hospital and were excluded from this analysis. Of the remaining 6,159 patients, also excluded were 290 patients who were not enrolled in Medicare Part A and Part B in 2002; 1,157 patients with physician claims indicating prior stroke diagnoses or receiving rehabilitation in 2002; and 108 patients who were not continuously enrolled in Medicare Part A and Part B until the end of this study (2006) or death, whichever came first. This left a final patient sample of 4,604. Among these, 1,166 patients (25.3%) were diagnosed with hemiparesis in 2003 (hemiparesis cohort) and 3,438 (74.7%) were not (nonhemiparesis cohort) (**Figure 1**).

The hemiparesis and nonhemiparesis cohorts did not differ significantly with respect to age and gender, however, the hemiparesis cohort was comprised of a higher proportion of African Americans than the nonhemiparesis cohort. Based on the presence of diagnosis codes in the year prior to their stroke hospitalization, more patients in the nonhemiparesis cohort were identified in the higher CCI categories than the hemiparesis cohort, indicating greater overall comorbidity status. However, when certain individual disease categories, which are thought to be risk factors for stroke, were assessed, such as cerebrovascular disease, congestive heart failure, diabetes, and diabetes with complications, no significant difference was observed between the two cohorts (**Table 1**).

Mortality

Nearly half of the study patients expired at the end of this study: 23.6% in the first year, 10.2% in the second, 8.4% in the third, and 7.2% in the fourth. The overall mortality rate in 4 years was significantly higher in the hemiparesis cohort (55.2% vs. 47.5%, $p < .01$). Survival time was plotted in Kaplan-Meier survival curves for both cohorts (**Figure 2**). The estimated probability of survival in the first year was 78.6% and 80.9% for the hemiparesis and nonhemiparesis cohorts, respectively. After the first year, the survival curves diverged with lower probability of survival observed for the hemiparesis cohort. This trend was sustained at the end of 4 years.

Medicare costs

Medicare per-patient costs in each year of follow-up were higher for the hemiparesis cohort. In 2003, Medicare costs for the hemiparesis cohort were nearly double those for the nonhemiparesis cohort ($45,875 vs. $25, 256; $p < .01$), and higher costs were observed across all care settings except for hospice. This trend continued over the study period for nearly all care settings (except for hospital outpatient care and physician services), underscoring significant incremental costs attributable to the long-term debilitating nature of hemiparesis.

When Medicare costs were categorized by care settings, hospital inpatient care represented the highest cost burden to Medicare. In both cohorts, inpatient care accounted for over 50% of the total costs in 2003 and hovered around 45% of the total

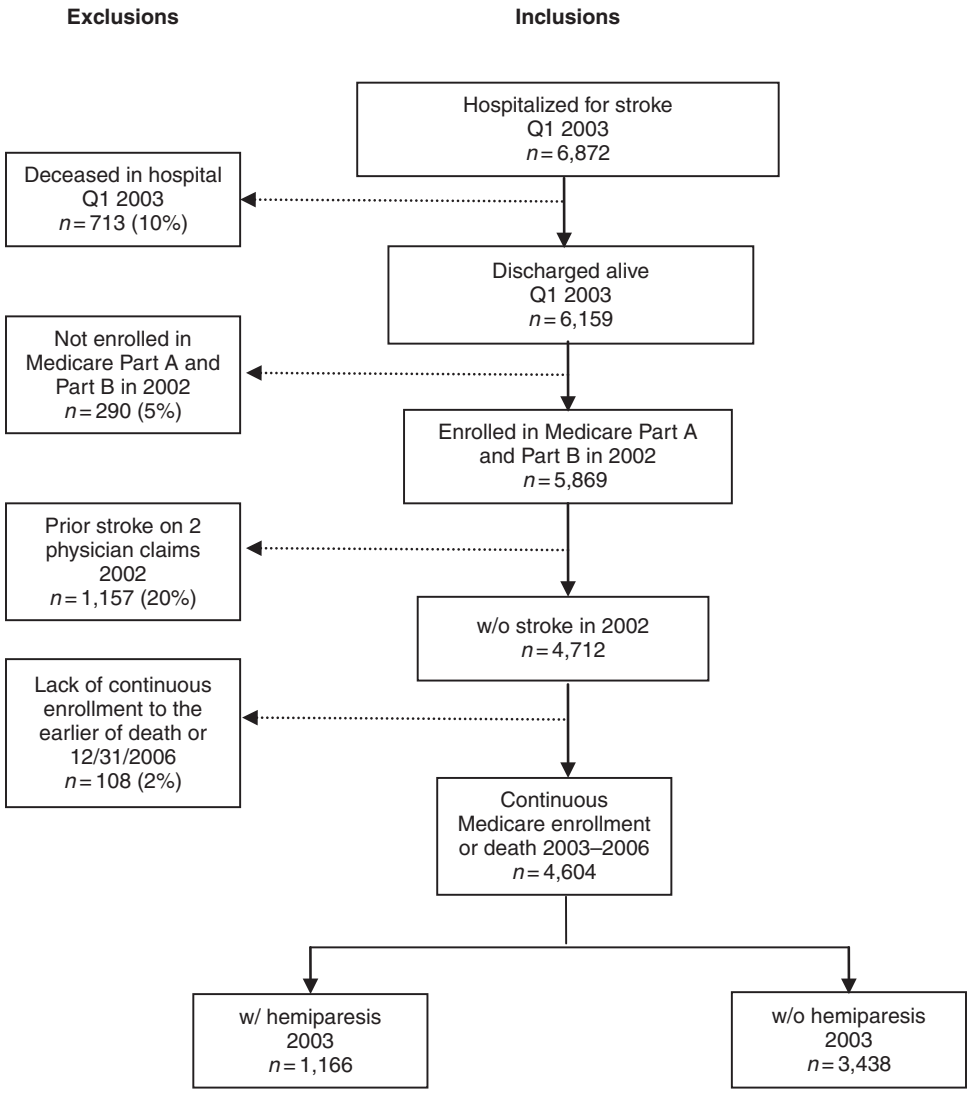

Figure 1. Study patients' identification and stratification.

cost in the following years. Physician care and SNFs were the second and third largest contributors to Medicare costs following hospital inpatient care, respectively (**Figure 3** and **Figure 4**).

Survival-adjusted 4-year total costs per patient were $77,143 for the hemiparesis cohort and $53,319 for the nonhemiparesis cohort. The difference in these Medicare costs was evident in the first 3 months of the stroke onset ($26,780 vs. $14,194) and sustained and aggrandized in the subsequent quarters. After the first stroke, costs in the first 3 months accounted for 35% and 27% of the total costs for the hemiparesis and nonhemiparesis cohorts, respectively. Follow-up care after the first 3 months represented over two thirds of the total costs in both cohorts (**Figure 5**).

Rehabilitation

A significantly higher proportion of the patients in the hemiparesis cohort received rehabilitation in each year than the nonhemiparesis cohort (**Figure 6**). In 2003, 33% of hemiparesis patients received rehabilitation in hospital inpatient units (i.e., acute care, LTAC, and IRFs), 32% in hospital outpatient facilities, 44% in SNFs, and 39% in HHAs. For those who received rehabilitation, average costs for rehabilitation in the hemiparesis cohort were $17,680, $6,947, $7,744, and $7,782 in 2003, 2004, 2005, and 2006, respectively. In comparison, the nonhemiparesis cohort incurred significantly lower average costs in 2003 ($7,841) but

Table 1. Patient baseline characteristics

Characteristic	w/ Hemiparesis (*n* = 1,166)	w/o Hemiparesis (*n* = 3,438)	*p*
Age, *n* (%)			
≤60	48 (4.1)	124 (3.6)	.42
61–70	123 (10.6)	330 (9.6)	
71–80	419 (35.9)	1,197 (34.8)	
>80	579 (49.4)	1,787 (52.0)	
Gender, *n* (%)			
Male	464 (39.8)	1,392 (40.5)	.68
Race, *n* (%)			
Caucasian	917 (78.6)	2,943 (85.6)	<.001
African American	184 (15.8)	364 (10.6)	
Hispanic/Latino	29 (2.5)	71 (2.1)	
Others	36 (3.1)	60 (1.8)	
Charlson Comorbidity Index, *n* (%)			
0–1	671 (57.6)	1818 (52.9)	.02
2–3	315 (27.0)	1053 (30.6)	
≥4	180 (15.4)	567 (16.5)	
Comorbidity, *n* (%)			
Cerebrovascular disease	236 (21.6)	651 (19.7)	.19
Congestive heart failure	228 (20.9)	702 (21.3)	.76
Diabetes	359 (32.9)	985 (29.9)	.07
Diabetes with complications	89 (8.2)	239 (7.3)	.33

Note: t tests for continuous variables and chi-square tests for categorical variables.

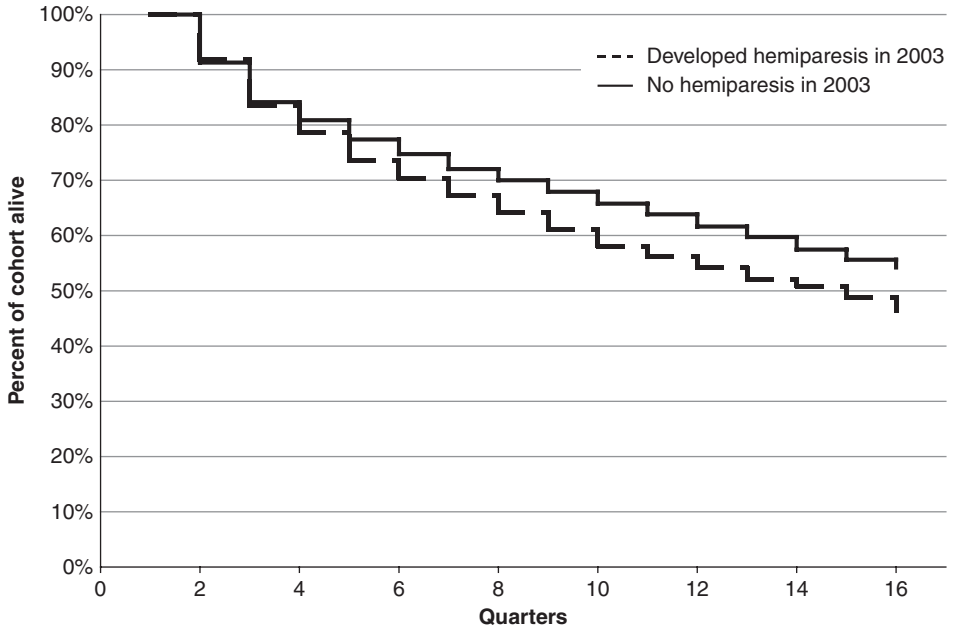

Figure 2. Kaplan-Meier survival analyses for patients in the hemiparesis and nonhemiparesis cohort.

comparable costs in the following years, averaging $7,304, $7,930, and $6,976, in 2004 through 2006. The majority of rehabilitation costs were incurred in 2003 for both cohorts (82.3% for the hemiparesis cohort; 67.3% for the nonhemiparesis cohort).

When Medicare costs were aggregated, the inpatient setting contributed to the largest portion

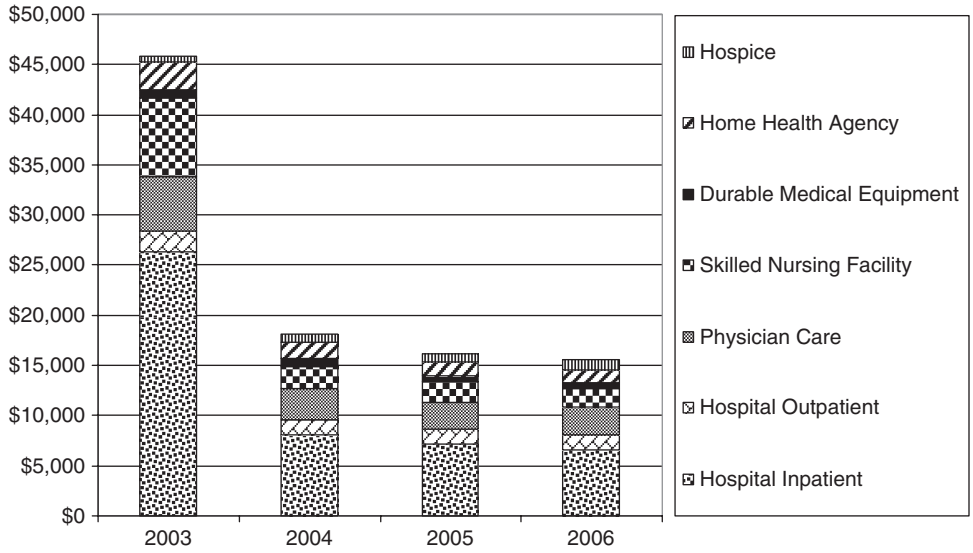

Figure 3. Share of total cost per patient by setting of care, hemiparesis cohort.

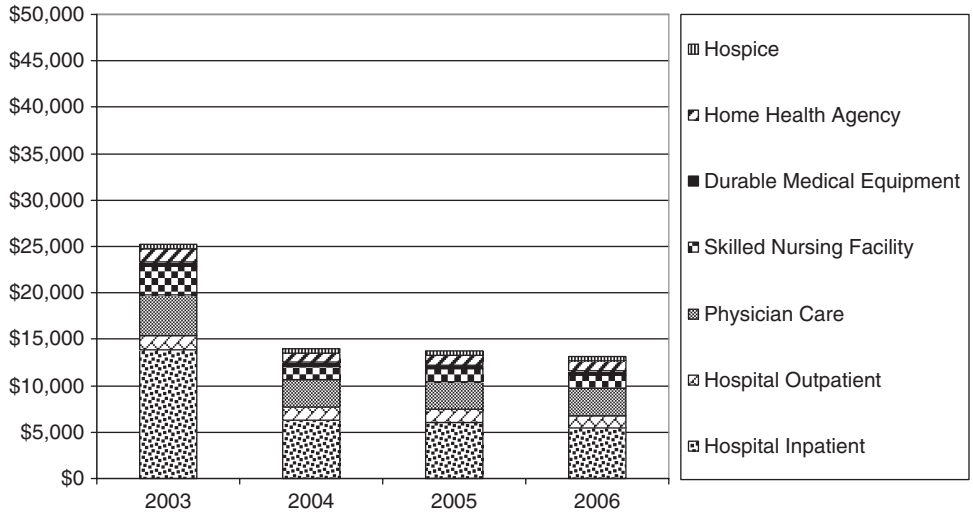

Figure 4. Share of total cost per patient by setting of care, nonhemiparesis cohort.

of rehabilitation costs for the hemiparesis cohort in 2003. In the following years, SNFs were the largest share of costs, followed by HHAs (**Figure 7**). In the nonhemiparesis cohort, SNFs and HHAs were consistently the first and second largest contributors to rehabilitation costs for all four years (**Figure 8**).

Discussion

This observational, longitudinal study followed patients who survived their initial stroke hospitalizations for 4 years. A population-based, nationally representative claims database was used to understand the long-term clinical and economic implications of stroke and stroke-related hemiparesis in the US Medicare system. In a large cohort of 4,604 patients, this study characterized 4-year mortality and provided detailed information on overall treatment costs, costs across different care settings, and rehabilitation use in different settings and associated costs. While the clinical and economic burden of stroke is widely recognized, the findings from this study extend the results of previous work, underscoring that among stroke

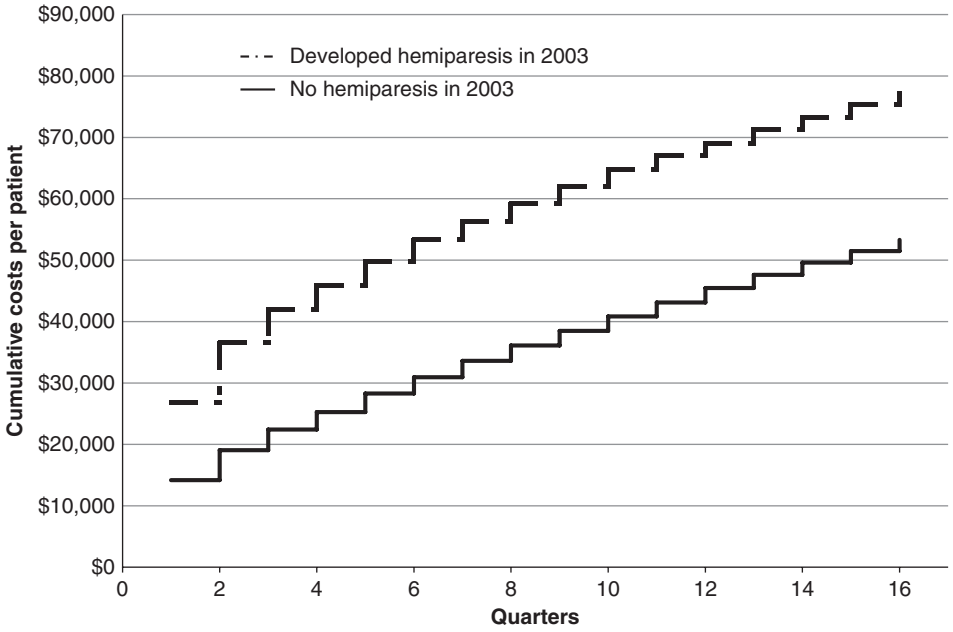

Figure 5. Cumulative costs for patients in the hemiparesis and nonhemiparesis cohort.

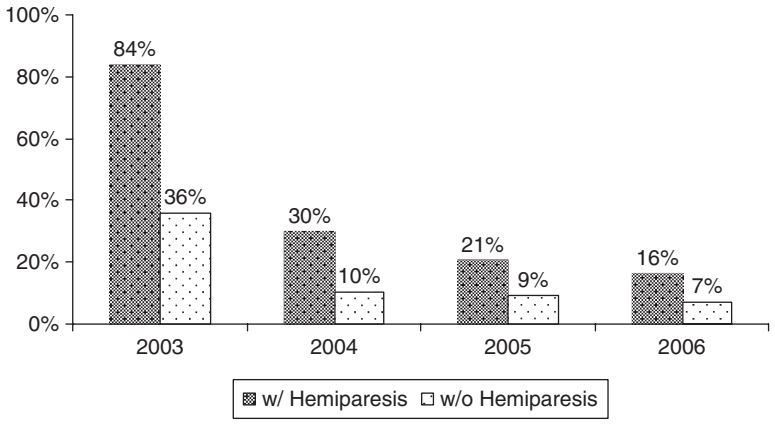

Figure 6. Percentage of cohort with rehabilitation use.

survivors those who developed hemiparesis are at a higher risk of death and consume greater health care resources than their counterparts without hemiparesis. Furthermore, to our knowledge, this is the first attempt to provide population-based estimates of the prevalence of both acute and long-term stroke rehabilitation use in stroke patients.

This study estimated a 4-year mortality rate of nearly 50% following an initial stroke hospitalization. This result is consistent with the findings of a community-based Copenhagen stroke study (58.4% at 5 years)[18] and a study of Medicare patients discharged from a VA hospital in Connecticut (52.6% at 5 years)[19] but is higher than the Northern Manhattan Stroke Study (41% at 5 years).[20] Because this study was based on a nationally representative, geographically diverse sample of patients who were treated at a variety of hospitals (academic and community), findings in this study can be generalized more than in other works. Moreover, patients in the hemiparesis cohort were shown to have a significantly higher mortality rate than those in the nonhemiparesis cohort in the first year, and the gap between the mortality rates within the two cohorts widened in subsequent years. This attests the clinical

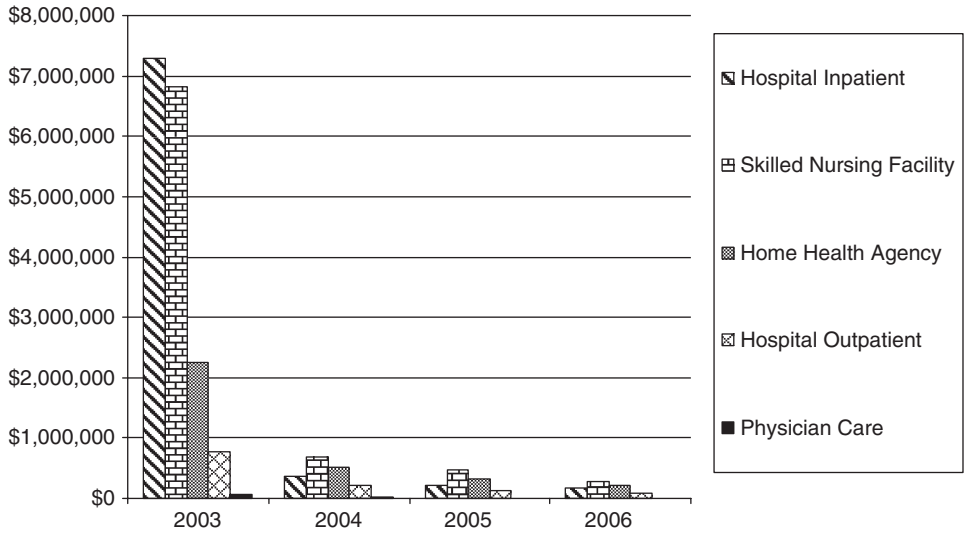

Figure 7. Total rehabilitation costs by setting, hemiparesis.

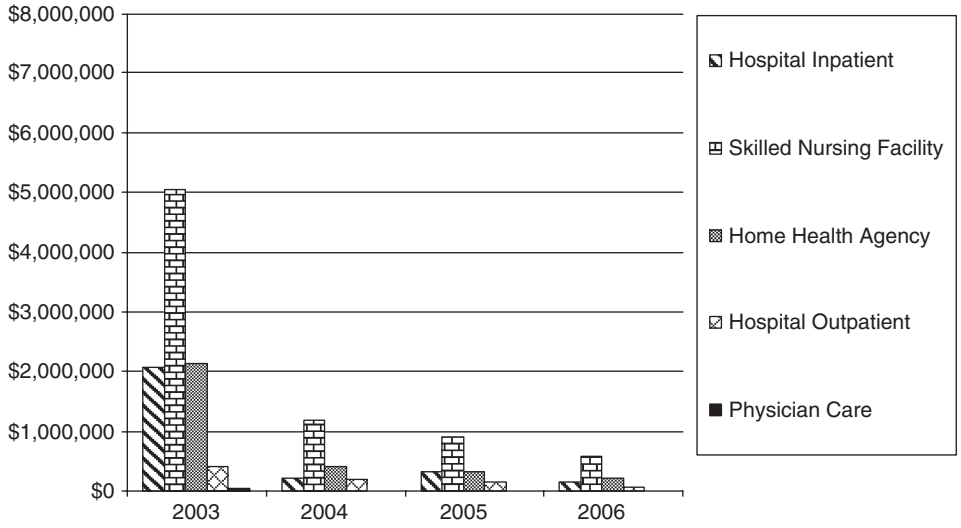

Figure 8. Total rehabilitation costs by setting, nonhemiparesis.

significance and the long-term debilitating nature of hemiparesis.

To date, most economic studies of stroke have focused on acute management of stroke victims. A study from 2003 indicated that ambulatory costs of stroke may be more important than costs of the acute phase when the cost-effectiveness of long-term secondary prevention is evaluated.[21] However, few studies have focused on the long-term economic consequences of stroke. Furthermore, studies that attempted to measure these outcomes either included a relatively small sample size or covered a limited number of study centers or health plans. Studies that analyzed cost drivers of stroke care also reached diverse conclusions. For example, a study in The Netherlands reported that the majority of costs were due to long-term care (i.e., nursing home and rehabilitation accounted for half of the total costs),[22] while another study incorporating data from 13 countries did not find long-term care to be the major cost driver.[23] This study suggests the costs in the first 3 months constituted about a third of the total costs in 4 years. While the importance of acute care has been clearly

demonstrated in other reports and corroborated in this study, one can not overlook or discount stroke follow-up care that constitutes nearly two thirds of the total costs. The opportunity exists to reduce the burden of poststroke morbidity and the length of time to recover from stroke.

The assessment of total Medicare costs per stroke patient is slightly higher than what was reported by Lee et al based on an analysis of SAF from 1996 to 2001.[24] This study estimated that the 4-year per patient costs were $53,319 and $77,143 for the nonhemiparesis and hemiparesis cohorts, respectively, whereas Lee et al reported the 5-year costs ranged from $49,666 to $60,177 for patients with ischemic and hemorrhagic stroke. Although the differences may be due in part to inflation, this study, using SAF 2003–2006, provides a more current picture of health care resource utilization and associated costs for the elderly stroke patients in the United States.

With respect to rehabilitation, this study found that 83.5% of hemiparesis patients received some type of rehabilitation following their hospital discharges in the first year. The rate was 30.0%, 20.8%, and 16.4% in the subsequent years. The corresponding rates for patients without hemiparesis were significantly lower in each year. In the first year, 33% of hemiparesis patients received rehabilitation in hospital inpatient units, 32% in hospital outpatient facilities, 44% in SNFs, and 39% in HHAs. To our knowledge, the only published study that assessed the prevalence of rehabilitation among stroke survivors is the 2005 Behavioral Risk Factor Surveillance System (BRFSS) survey on stroke survivors in 21 states and the District of Columbia, which found that about 30% of stroke survivors received outpatient rehabilitation.[3] Recent clinical practice guidelines recommend outpatient rehabilitation for stroke survivors who have been discharged from inpatient rehabilitation facilities and for less severe stroke survivors who have been discharged after acute care. Based on these guidelines, the majority of stroke survivors should receive outpatient rehabilitation following stroke.[25] Findings from this study and the BRFSS survey indicate that the prevalence of stroke survivors receiving outpatient rehabilitation is lower than would be expected if clinical practice guideline recommendations for all stroke patients had been followed. As timely, intensive, and organized rehabilitation has been demonstrated to substantially improve patients' functional outcomes and quality of life after an acute stroke, increasing the number of stroke survivors who receive needed outpatient rehabilitation as well as rehabilitation in other settings may lead to better functional status and quality of life in this population.

There are a number of limitations in the analysis of the Medicare SAF data. First, we acknowledge the limitation of using administrative claims to accurately ascertain diagnosis and sufficiently identify resource use and costs, because these data are collected for the purpose of making health care payments instead of clinical research. For example, approximately 25% of the stroke survivors were coded with hemiparesis in this study while other studies suggest that among stroke survivors 50% have some hemiparesis following stroke.[1] It is possible that signs or symptoms related to hemiparesis may not have been captured in the claims, if the coding of hemiparesis does not trigger a higher Medicare payment for that episode of care. Similarly, the measurement of rehabilitation and other resource use depends upon the design of the Medicare fee-for-service plan and its scope of coverage. For example, Medicare covers up to 100 days of care in an SNF for each beneficiary per coverage period, therefore, long-term stay in SNFs could not be assessed in this study. In addition, the interpretation of rehabilitation use and assignment of associated costs are challenging. Due to lack of detailed clinical information from the administrative data, the classification of rehabilitation was based on procedure codes identified in payer policies and clinical guidelines. When using procedure codes to identify a resource used, the reason for such use is not always established. For example, if a stroke survivor who also had joint replacement surgery received inpatient rehabilitation, it is not possible to determine whether the rehabilitation was for the stroke recovery or for the joint replacement surgery. Therefore, to increase the specificity of attributing rehabilitation to stroke or stroke-related hemiparesis, a claim had to contain both a rehabilitation procedure code and a diagnosis code suggesting cerebrovascular disease to be included in this analysis. Additionally, we applied different methods to characterize the costs associated with rehabilitation in different care settings. In LTAC, IRFs, and SNFs, fixed payment amounts are established in advance based on the typical cost

of treating a patient with a particular diagnosis via DRG or RUG classification; therefore, an "episodic payment" was included in the cost of rehabilitation. While rehabilitation was rendered in hospital outpatient facilities and HHAs, we included the Medicare payment for the entire claim with a rehabilitation procedure code as the cost of rehabilitation, instead of the amount paid under that rehabilitation code. It is, therefore, possible that costs of resource use unrelated to rehabilitation were included in the analysis.

Second, this study only evaluated the burden of caring for stroke survivors from the perspective of the Medicare system. Premiums, deductibles, and co-insurance as well as costs for prescription drugs were not included. Third, when patients are followed for 4 consecutive years, serial dependency is likely to be observed (e.g., patients with higher costs in the previous year are likely to incur higher costs in several years to come). It is also possible that the higher costs observed in the hemiparesis cohort were partly due to the presence of other conditions. However, we assessed the comorbidity status for all patients prior to selecting them for analysis, and no significant differences were detected between the two study cohorts with respect to the disease categories that are independent risk factors for stroke. Finally, we excluded patients who died during the initial stroke hospitalization as those patients might have incurred significant costs due to end-of-life support that is usually furnished to those who expire in the hospital. Because the goal of this study is to characterize the long-term burden of stroke and the impact of hemiparesis on stroke patients and the Medicare system, patients who died during the acute hospitalization were excluded. Had these patients been included, the estimated mortality and Medicare costs would have been higher.

Conclusion

This retrospective study provides a most recent analysis of the mortality and the cost of stroke and stroke-related hemiparesis in the US Medicare system. Long-term care and rehabilitation services constituted a significant proportion of total medical costs. The management of stroke survivors should evaluate clinical and economic impacts, especially costs incurred beyond the initial hospitalization.

Acknowledgments

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REFERENCES

1. Lloyd-Jones D, Adams R, Carnethon M, et al. Heart disease and stroke statistics–2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation.* 2009;e21–181.
2. Duncan PW, Zorowitz R, Bates B, et al. Management of adult stroke rehabilitation care: a clinical practice guideline. *Stroke.* 2005;e100–e143.
3. Outpatient rehabilitation among stroke survivors–21 States and the District of Columbia, 2005. *MMWR.* 2007;504–507.
4. Adams HP Jr, Brott TG, Crowell RM, et al. Guidelines for the management of patients with acute ischemic stroke. A statement for healthcare professionals from a special writing group of the Stroke Council, American Heart Association. *Circulation.* 1994;1588–1601.
5. Gresham GE, Duncan PW, Stason WB, et al. *Post-Stroke Rehabilitation: Clinical Practice Guideline Number 16*. AHCPR Publication No. 95-0662;1995.
6. Ryan AS, Dobrovolny CL, Smith GV, Silver KH, Macko RF. Hemiparetic muscle atrophy and increased intramuscular fat in stroke patients. *Arch Phys Med Rehabil.* 2002;1703–1707.
7. Hankey GJ, Jamrozik K, Broadhurst RJ, Forbes S, Anderson CS. Long-term disability after first-ever stroke and related prognostic factors in the Perth Community Stroke Study, 1989–1990. *Stroke.* 2002;1034–1040.
8. National Stroke Association. Hemiparesis. Available at: http://www.stroke.org/site/PageServer?pagename=hemiparesis. Accessed June 2009.
9. Patel MD, McKevitt C, Lawrence E, Rudd AG, Wolfe CD. Clinical determinants of long-term quality of life after stroke. *Age Ageing.* 2007;316–322.
10. Taylor TN, Davis PH, Torner JC, Holmes J, Meyer JW, Jacobson MF. Lifetime cost of stroke in the United States. *Stroke.* 1996;1459–1466.
11. Organised inpatient (stroke unit) care for stroke. *Cochrane Database Syst Rev.* 2007;CD000197.
12. Langhorne P, Duncan P. Does the organization of postacute stroke care really matter? *Stroke.* 2001;1268–1274.
13. Kramer AM, Steiner JF, Schlenker RE, et al. Outcomes and costs after hip fracture and stroke. A comparison of rehabilitation settings. *JAMA.* 1997;396–404.

14. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;373–383.
15. Tessier A, Finch L, Daskalopoulou SS, Mayo NE. Validation of the Charlson Comorbidity Index for predicting functional outcome of stroke. *Arch Phys Med Rehabil.* 2008;1276–1283.
16. Goldstein LB, Samsa GP, Matchar DB, Horner RD. Charlson Index comorbidity adjustment for ischemic stroke outcome studies. *Stroke.* 2004;1941–1945.
17. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol.* 1992;613–619.
18. Kammersgaard LP, Olsen TS. Cardiovascular risk factors and 5-year mortality in the Copenhagen Stroke Study. *Cerebrovasc Dis.* 2006;187–193.
19. Bravata DM, Ho SY, Brass LM, Concato J, Scinto J, Meehan TP. Long-term mortality in cerebrovascular disease. *Stroke.* 2003;699–704.
20. Hartmann A, Rundek T, Mast H, et al. Mortality and causes of death after first ischemic stroke: the Northern Manhattan Stroke Study. *Neurology.* 2001;2000–2005.
21. Spieler JF, De Pouvourville G, Amarenco P. Cost of a recurrent vs. cost of first-ever stroke over an 18-month period. *Eur J Neurol.* 2003;621–624.
22. Bergman L, van der Meulen JH, Limburg M, Habbema JD. Costs of medical care after first-ever stroke in The Netherlands. *Stroke.* 1995;1830–1836.
23. Caro JJ, Huybrechts KF. Stroke treatment economic model (STEM): predicting long-term costs from functional status. *Stroke.* 1999;2574–2579.
24. Lee WC, Christensen MC, Joshi AV, Pashos CL. Long-term cost of stroke subtypes among Medicare beneficiaries. *Cerebrovasc Dis.* 2007;23(1):57–65.
25. Rodin M, Saliba D, Brummel-Smith K. Guidelines abstracted from the Department of Veterans Affairs/Department of Defense clinical practice guideline for the management of stroke rehabilitation. *J Am Geriatr Soc.* 2006;158–162.

Appendix

Codes used for defining utilization of therapy and rehabilitation

Settings	Code Type	Code	Descriptor
Hospital Inpatient	ICD-9-CM	V57xx	Care involving use of rehabilitation procedures
	DRG	462	Rehabilitation
Hospital Outpatient and PC	CPT	92506, 92507, 92508	Evaluation or treatment of speech, language, voice, communication and/or auditory processing
		97001, 97002	Physical therapy evaluation
		97003, 97004	Occupational therapy evaluation
		97010–97039	Application of a modality to one or more areas including, but not limited to thermal, acoustic, light mechanical or electric energy
		97110-97546	Therapeutic procedures one or more areas
		97703, 97750	Tests of measures of physical performance
		97780, 97781, 97799	Other physical medicine/rehabilitation services/procedures
	HCPCS	G0129	Occupational therapy requiring the skills of a qualified occupational therapist, furnished as a component of a partial hospitalization treatment program, per day
	ICD-9-CM	V57xx	Care involving use of rehabilitation procedures
SNF	ICD-9-CM	V57xx	Care involving use of rehabilitation procedures
	RUG	First three digits in: RHA, RHB, RHC, RLA, RLB, RMA, RMB, RMC	Low/medium/high rehabilitation
		RUA, RUB, RUC, RVA, RVB, RVC	Very high/ultra high rehabilitation
HHA	HCPCS	G0151-G0153	Physical, occupational, speech and language in home health setting, each 15 minutes
		S8990	Physical or manipulative therapy performed for maintenance rather than restoration
		S9128, S9129, S9131	Speech, occupational, physical therapy at home, per diem
	ICD-9-CM	V57xx	Care involving use of rehabilitation procedures

Note: CPT = current procedural terminology; DRG = Diagnosis-Related Group; HCPCS = Healthcare Common Procedure Coding System; HHA = home health agency; ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; PC = physician care; SNF = skilled nursing facility; RUG = resource use group.